NATIONALE
PLATTFORM
ELEKTROMOBILITÄT

The German Standardisation Roadmap for Electromobility – Version 3.0

AG 4 – Standardisation and Certification

Contents

1 Executive Summary

For Germany to improve on its competitive lead in the international electromobility market, and to ensure that the development and added value of this technology remains in this country, a major focus must be placed on furthering and combining these developments in a target-oriented manner. If German industry is to position itself successfully, it is essential in this context that the positive effects of standardisation be incorporated into the development process right from the start so that they can be fully exploited.

Standardisation in the field of electromobility is characterised by several features distinguishing it from previous standardisation processes. The special challenge lies in coordinating and integrating diverse activities in different sectors in order to effectively meet demands. Electromobility is a breakthrough innovation that requires new, comprehensive systematic thinking. Up to now, standards and specifications in the domains of electrical engineering/energy technology and automotive technology have been viewed separately. So far there has been little attempt to view them in an integrated manner, although this would be an important approach, particularly because these domains are merging, resulting in new points of contact and interfaces.

The present version 3.0 of the German Standardisation Roadmap for Electromobility is a continuation of the first German Standardisation Roadmap for Electromobility, which was presented in autumn 2010 [11]. It addresses the latest developments in electromobility and their framework conditions, referring to ongoing, necessary standardisation activities. The German Standardisation Roadmap for Electromobility reflects the general agreement among all actors in the electromobility sector. Automobile manufacturers, the electrical industry, energy suppliers/grid operators and information network providers contributed and technical associations and public authorities were involved in the preparation of this document. Therefore, the German Standardisation Roadmap for Electromobility represents the German standardisation strategy for this area.

References to the relevant regulations are given in the report of the "Vorschriftenentwicklung" (regulatory developments) team of NPE/Working Group 4 [9]. Below is a summary of the recommendations made in this paper for the promotion of a wider use of electromobility:

General recommendations

Political action is needed at a European and international level

The close networking of research and development and of regulatory and legislative frameworks with standardisation is necessary. National standardisation and regulation carried out by certain countries must not impede harmonisation at an international level.

Standardisation must be timely and international

At present, national and international standardisation concepts compete with one another. However, since road vehicle markets are international, efforts must aim towards developing international standards right from the start. The same applies to interfaces between electric vehicles and the infrastructure. Standardisation a at national or European level alone is considered to be inadequate. It is essential that national standards proposals be processed quickly and that German results are transferred to international standardisation as soon as possible.

General recommendations	**Coordination and focussing is absolutely imperative**	Electromobility is shaped by a number of actors and specialist areas. Thus, an interdisciplinary collaboration and coordination by the existing steering committee EMOBILITY (DKE/NAAutomobil) and the Electromobility committee at DIN is important to avoid duplication of work. New committees must not be founded but the existing committees in DIN and DKE have to be strengthened.
	Standardisation must be clear and defined	In order to promote innovation, standardisation must relate to functionality and provisions regarding technical solutions must be avoided ("performance-based rather than descriptive"). However, technical solutions must be determined in order to ensure the required interoperability for interfaces standards (e.g. between vehicle and grid infrastructure
	A uniform worldwide charging infrastructure is necessary (interoperability)	It must be possible to charge electric vehicles "everywhere, at all times": interoperability of different makes of vehicles with the infrastructure provided by various operators must be ensured. The standardisation of charging techniques and billing/payment systems must ensure the development of a charging interface that is user-oriented, uniform, safe and easy-to-operate. User interests must have priority over the interests of individual companies.
	Existing standards must be used and further developed without delay	There are already a great number of relevant standards in the "automotive engineering", "information and communications technology" and "electrical engineering" sectors. These must be appropriately utilised and made known. Providing information on these standardisation activities and their status are a vital part of this Standardisation Roadmap. Moreover, the necessary work should focus less on initiating new standards projects than on expanding/adapting existing standards and specifications to the needs of electromobility. Interdisciplinary cooperation at an international level is required particularly for the standardisation of interfaces.

Participation in European and international standardisation is essential

In order to achieve our aims – and to ensure our active influence – a greater participation at a national and international level is needed. This means that German companies must play a greater part in German, European and international standards work. Standards work is to be seen as an integral component of R&D projects and thus eligible for funding.

General recommendations

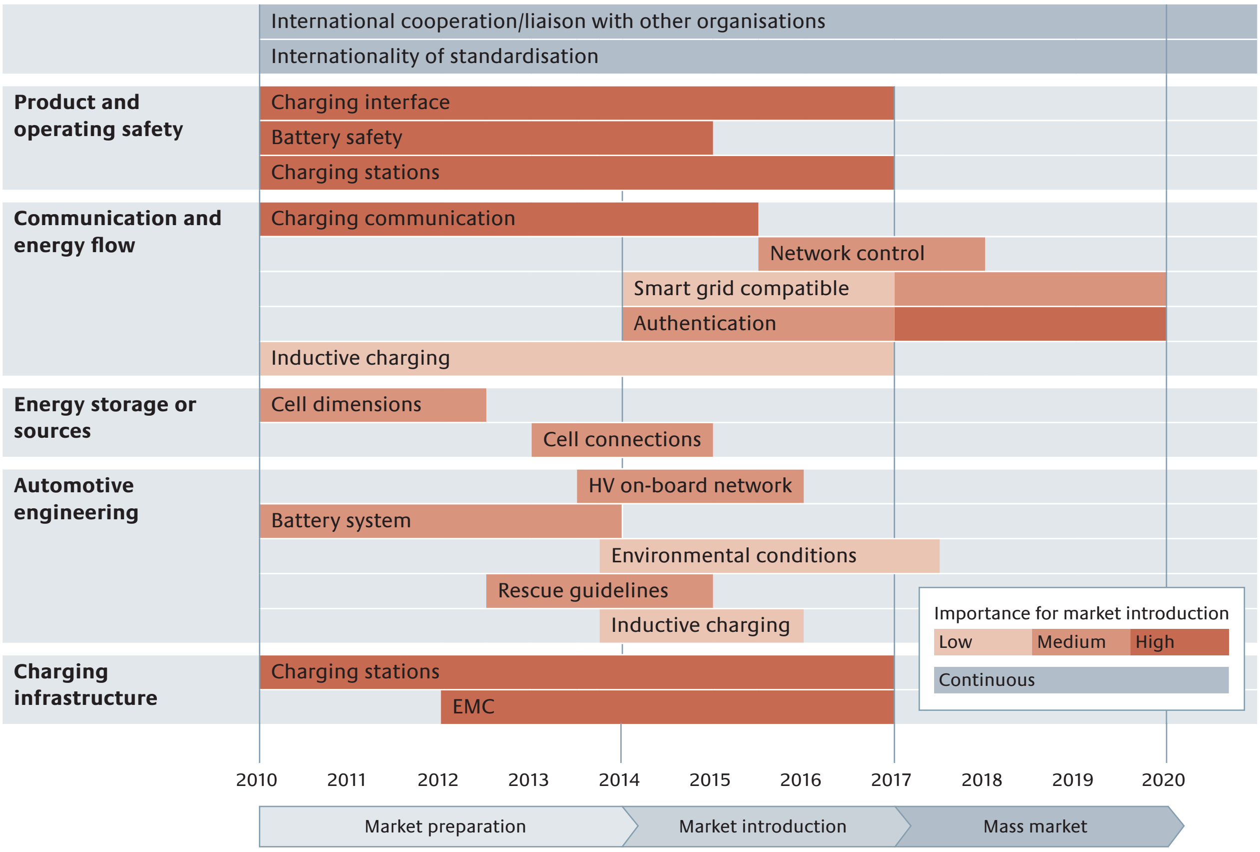


Figure 1: Schedule for implementation of topics of the standardisation roadmap

2 Initial Situation for the German Standardisation Roadmap for Electromobility

Fossil energy sources represent an important aspect for people's energy supply. Their availability, for example in the form of petroleum for combustion engines, is decreasing which is resulting in increasing prices. Additionally, exhaust gases produced during combustion have a negative effect on our environment. Therefore, in order to be able to sustainably meet the mobility demands of people in the future, energy must be supplied from environmentally friendly sources. Thus, the future of energy supply lies in sustainable energy sources that are politically reliable and available in the long-term, and whose ecological "footprint" is minimal. If electromobility uses these sustainable energy sources, it will help to set the course for a future worth living. By establishing cycles and processes that treat resources with care, progress will be promoted effectively while the same standard of comfort the users are used to is maintained.

This chapter describes the areas of application and vehicles classes as well as the structure of the specification and standardisation environment. Finally, regulation in the areas of automobile technology and hazardous materials transportation as well as the power supply industry and the Standard Weights and Measurement Law will be considered.

2.1 Introduction

The subject of alternative means of propulsion and electromobility is gaining global importance. It is one of the most essential and urgent issues affecting the future of Germany as a technological stronghold, for which the public sector as well as standardisation and specification must provide framework conditions.

To make electricity from renewable energy sources readily available for use in electric vehicles, a strategic concept for short, medium and long-term solutions to the approaching challenges is needed. As regards electric-drive vehicles, thinking globally is first and foremost a question of key technical parameters: charging performance, charging interfaces, and battery capacity. Ultimately, functionality, price, ecological awareness and responsibility across national borders will determine the level of user acceptance. But above all, there is a need for "round tables" at which the various actors can work together to make progress, implementing this progress in standards and specifications, which can be used as a basis for further developments. Automobile manufacturers, energy suppliers, grid operators and research institutes have long realised how closely knit the electromobility network really is. The electric vehicle of the future will be a decisive element of the "smart grid". Many new interfaces are emerging which will provide an opportunity to developed existing interfaces further. The main objective is to define efficient payment systems for recharging procedures that everyone should be able to follow, at least on a European scale, and preferably globally.

The large number of national and international projects makes a systematic and transparent strategy for providing information necessary, especially to prevent synergy effects from falling victim to false ambitions in the name of competition. Unilateral action is obviously just as ineffective as an attempt to conjure up, or simply wait for successful solutions.

Electromobility is a much-discussed topic among German and international experts. Due to the increased complexity brought about by the gradual merging of the automotive and electrical engineering sectors, only an overall concept in which timeframes are specified is suitable. However, it quickly becomes evident that there is not always sufficient interoperability among the various trades. This can only be achieved by defining standards and specifications.

The aim of this document is to present

- the technically-oriented standardisation roadmap for the German electromobility vision,
- an overview of existing standards and specifications in this field, current activities of the involved standardisation committees,
- standardisation requirements and how they are addressed and
- the implementation of the formulated activity recommendations.

Thus, the document serves as an introduction for interested readers as well as a reference for active experts.

In accordance with the German Standardisation Strategy [2][3], a differentiation is made in German between “Normung” (“standardisation”, “formal standardisation”, “consensus-based standardisation”) i.e. the development, on the basis of full consensus, of rules, guidelines and characteristics for activities for general or repetitive application by an approved organisation – and “Standardisierung” (“informal standardisation”, “limited consensus standardisation” or “consortial standardisation”), i.e. the process of drawing up non-consensus based specifications. The latter are published as several types of document, for example a VDE application guide, DIN SPEC (DIN Specification), PAS (publicly available specification), ITA (industry technical agreement) or TR (technical report).

Electromobility is dealt with in federally funded programmes such as “ICT for electromobility II: Smart Car – Smart Grid – Smart Traffic” (funded by the Federal Ministry of Economics and Technology (BMWi)), “Fraunhofer system research on electromobility” (funded by the Federal Ministry of Education and Research (BMBF)) and “Electromobility in pilot regions” (funded by the Federal Ministry of Transport, Building and Urban Development (BMVBS)). Many expert groups and research projects cover this topic as well, and several high-ranking politicians and representatives of commerce and industry are involved in the “National Platform for Electromobility (NPE)”. This German Standardisation Roadmap for Electromobility Version 3.0 was developed on behalf of Working Group 4 (NPE AG4) “Standardisation and Certification” of the NPE under the leadership of the working group DKE/EMOBILITY.30 in which all stakeholders are represented, such as the technical associations VDA, VDE and ZVEI. Once the German Standardisation Roadmap for Electromobility has been released by the NPE AG4 it should be presented to the professional public, e.g. at congresses and symposia. The German Standardisation Roadmap for Electromobility is is to be updated regularly on the basis of new findings, for example from research projects, work in standardisation bodies, or work within the symposia. This will give experts the opportunity to take part in this process by submitting comments and participating in standardisation, even after publication of this document.

The following sections describe the current national and international standardisation landscape. Subsequently, the reasons and framework conditions which have led to the development of this German Standardisation Roadmap for Electromobility are discussed. They include a list of the expected benefits and agreed international procedures for standardising electromobility. Next, an overview of the overall system with regard to “electromobility” as expected in phase 1 (one million electric vehicles by 2020) is provided, and the current status of the standardisation process as well as an outlook for the continuation of the German Standardisation Roadmap for Electromobility in phase 2 are described. Further reading, lists of terms, definitions and abbreviations as well as an overview of the standards, specifications and standardisation committees are provided in Annex A to D. The generally updated Annex E complements this document and contains the specific activity recommendations of the German Standardisation Roadmap for Electromobility contained in the main text as well as their evaluated urgency based on their level of implementation.

2.2 Scope of the Roadmap and vehicle classes

The German Standardisation Roadmap for Electromobility covers the vehicle categories M, N and L as well as electric bicycles, i.e. all classes of two- to four-wheel vehicles, including commercial and utility vehicles and buses in accordance with the European Directive 2007/46/EG as well as the regulation criteria (EU) No. 168/2913).

2.3 Structure of the standardisation landscape

Standards and specifications are developed at various levels (national, European, international) in a number of organisations. To provide a better understanding, an overview of the various standards organisations and their interrelations is given below. ISO and IEC, which constitute the main standardisation landscape for this German Standardisation Roadmap for Electromobility, and their counterparts at a European and national level, are described in more detail. Figure 2 shows the relationship between the various standards organisations, together with their regulatory bodies.

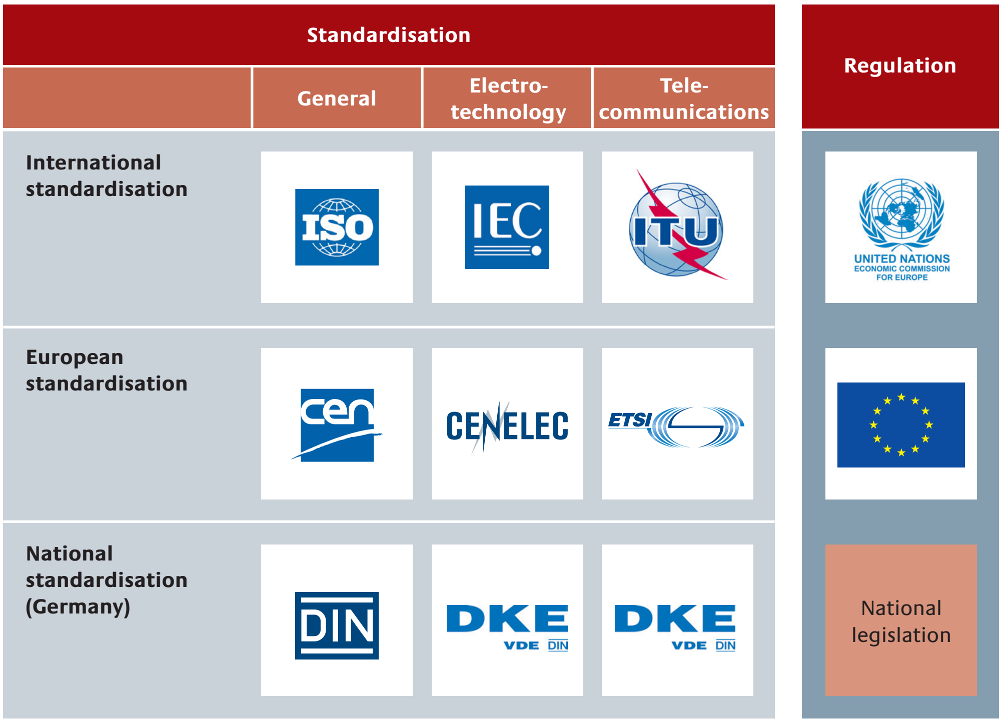


Figure 2: Main elements of the standardisation landscape and relationships with their regulatory bodies

In terms of full consensus-based standardisation, ISO, IEC and ITU-T are the authoritative standards organisations. The corresponding standards organisations at a European and national level are CEN and DIN (including NAAutomobil, the Road Vehicle Engineering Standards Committee), and CENELEC, ETSI and the DKE. The respective national standards organisations are members of ISO, IEC, CEN and CENELEC.

SAE and ANSI (American National Standards Institute) are examples of other organisations outside of the official structures of ISO and IEC. SEA is an organisation that is represented mainly on the North American continent. Their standards are deemed as being not fully consensus-based in the sense of ISO/IEC standards and are therefore considered "specifications". They may have an essentially international orientation, but are nevertheless mainly of importance for North America. German automobile manufacturers and their suppliers must sometimes comply with SAE specifications in order to gain access to the North American market.

ANSI is the American member in international organisations such as ISO and IEC. However, ANSI does not develop standards itself. It relies on organisations accredited by ANSI such as e.g. UL.

UL is an independent organisation for product testing and certification that develops specifications with a focus on safety. UL is accredited by ANSI to develop national, full consensus-based US standards.

In addition to the organisations shown in Figure 2, there are a number of other organisations, many of which operate at a national or regional level only (e.g. the CAR 2 CAR Communication Consortium) and which should interact in networks for electromobility technology.

The internal structures of IEC and ISO and the respective European and national organisations as well as the principle of national reflection are shown in Figure 3. The following joint bodies were set up to coordinate the activities of the electrical engineering and automotive industries:

- International level: various Joint Working Groups (JWG) and Joint Technical Committees (JTC)
- European level: the joint CEN/CENELEC Focus Group on European Electromobility (FG-EV), an advisory body
- National level: the steering group on EMOBILITY (joint body of the DKE and NAAutomobil) and its subordinate bodies (GK, GAK).

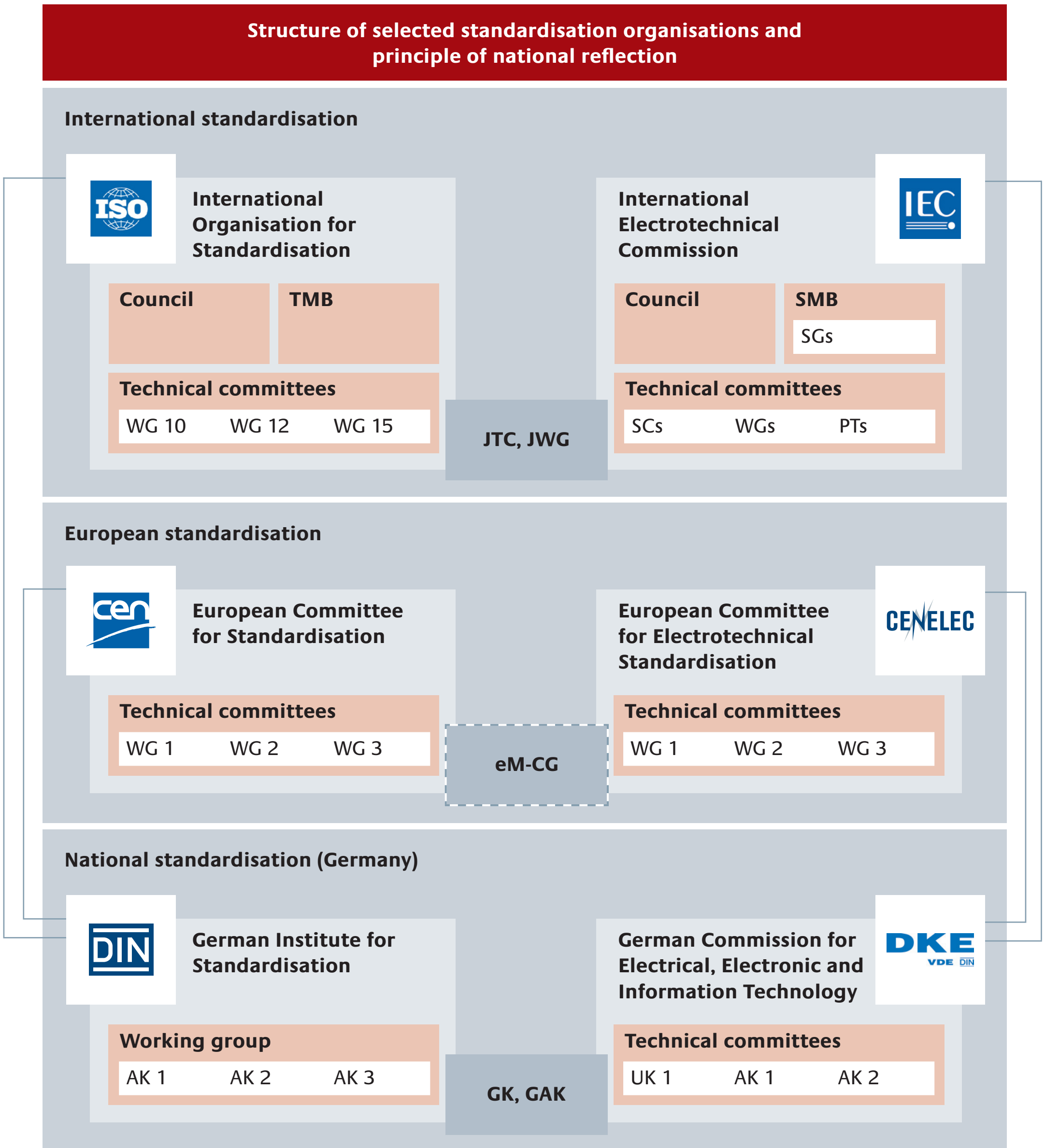


Figure 3: Internal structure of IEC/CENELEC/DKE and ISO/CEN/DIN, and the principle of national reflection

2.4 DIN, CEN and ISO

DIN, the German Institute for Standardisation, offers stakeholders a platform for the development of standards and specifications as a service to industry, the state and society. DIN is a private organisation which is registered as a non-profit association. Its members include businesses, associations, government bodies, and other institutions from industry, commerce, trade and science.

DIN's primary task is to cooperate with stakeholders' representatives to develop consensus-based standards that meet market requirements. By agreement with the German Federal Government, DIN is the acknowledged national standards body that represents German interests in European and international standards organisations.

Currently, almost 90 % of the standards work carried out by DIN are European and/or international in nature while the DIN staff members coordinate the entire non-electrotechnical standardisation process at a national level and ensure the participation of the relevant national bodies at a European and international level. DIN represents Germany's standardisation interests as a member of the European Committee for Standardisation (CEN) and the International Organisation for Standardisation (ISO). The DKE is a joint organ of DIN and VDE and represents Germany's interests in the field of electrical engineering as a member of the European Committee for Electrotechnical Standardisation (CENELEC) and the International Electrotechnical Commission (IEC).

The Road Vehicle Engineering Standards Committee of DIN (NAAutomobil) is supported by the German Association of the Automotive Industry (VDA) and is responsible for standardisation in all matters concerning automobiles, including accessories, parts from suppliers and systems. NAAutomobil mirrors international and regional standards work concerning automobiles within ISO/TC 22 and CEN/TC 301, and holds the secretariats of numerous working groups.

2.5 DKE, CENELEC and IEC

The DKE, German Association for Electrical, Electronic & Information Technologies in DIN and VDE, represents the interests of the electrical/electronic engineering and IT sectors in international and regional electrotechnical standardisation, with VDE being responsible for the DKE's daily operations. It is responsible for standards work in the respective international and regional organisations (primarily IEC, CENELEC and ETSI). It represents German interests in both the European Committee for Electrotechnical Standardisation (CENELEC) and the International Electrotechnical Commission (IEC). The DKE is a modern, non-profit service organisation promoting the safe and rational generation, distribution and use of electricity, serving the interests of the general public.

The DKE's task is to develop and publish standards in the fields of electrical engineering, electronics and information technology. The results of DKE work are published as DIN standards, which are included in the German standards collection. Where they contain safety-related provisions, they are also published as VDE specifications and are included in the VDE Specifications Code of Safety Standards.

DKE working bodies are German "mirror committees" and are attached to the relevant IEC (or CENELEC) technical committees, in such a way that only one German body is responsible for all national, European and international work and/or cooperation in each specialist area.

At a meeting of the IEC Standardisation Management Board (SMB) held in 2011, a decision was made to set up the IEC Strategic Group 6: "Electrotechnology for Mobility". The aim of this group is to support the IEC SMB in strategic issues concerning electromobility and in doing so to especially improve the interaction between electric vehicles and the power grid infrastructure. The final report of the group SG 6 was presented to the IEC SMB for decision.

2.6 Regulation in the fields of automotive engineering and dangerous goods transport

Safety and environmental protection matters concerning automotive vehicles and road transportation of dangerous goods are governed mainly by regulations developed at a European or international level. Standards play a less important role here or only serve to supplement regulations and directives.

In order for automotive vehicles to be licensed and approved in Germany, they have to comply with European directives and regulations. In future, these directives and regulations will increasingly refer to UN regulations or the Global Technical Regulations developed at an international level by the "World Forum for Harmonisation of Vehicle Regulations (WP.29)" of the United Nations Economic Commission for Europe (UN/ECE).

Those vehicle categories which are not subject to licensing and approval in line with the European directives and regulations have to comply with the Machinery Directive (Directive 2006/42/EC).

For safety reasons and to avoid the risk of fire and explosions, the transportation of lithium and lithium-ion batteries is subject to the requirements and regulations of international and European agreements and conventions on the transport of dangerous materials, such conventions being binding under international law.

Further details on these and other regulations and directives are described in a separate report of the "Vorschriftenentwicklung" (regulatory developments) team in NPE AG 4 [9].

2.7 Regulation in the energy industry and calibration regulations

The provisions of the German Energy Industry Act (EnWG) and laws on weights and measures have to be observed when electric energy is sold at any (AC, DC or inductive) charging station. (The terms "charging station" and "charging column" used in this document do not represent constructive suggestions and are used as established terms in the field of charging infrastructure.) If the charging station is connected directly to the power grid, compliance with the relevant technical connection conditions (the "Technischen Anschlussbedingungen (TAB)") is required. The correct measurement of electrical energy is regulated at a national level by the Energy Industry Act and by the Weights and Measures Act (Eichgesetz). In this context, standards can contribute towards common solutions for implementing the statutory framework.

§§ 21b to 21i, 40 of the Energy Industry Act and a further statutory instrument that still has to be passed in accordance with § 21i of the Energy Industry Act lay down minimum requirements on data security and data privacy as well as on the transparency and comprehensibility of the payment/billing system in connection with the sale of electricity for electromobility. These provisions take concrete form in a protection profile as well as technical regulations in the German Federal Office of Information Security's (BSI) Common Criteria Protection Profile and Technical Guidelines defining requirements for the safety and interoperability of a communication system for metering systems in accordance with the Energy Industry Act. According to the current draft of the Metering System Regulation, the charging infrastructure for electromobility is expected to be excluded until 2020, since the requirements may constrict the architecture of an efficient and economical charging infrastructure. In terms of electromobility, this regulatory framework must be seen as an essential element in ensuring the safety of smart grids and as a means of transposing the regulations set down in the EU's third internal market package on energy into national law.

The German Weights and Measures Act stipulates the requirements for the metrologically correct measurement of electricity being sold for electromobility purposes. Issues regarding the security and privacy of the measured data are addressed by the regulatory framework set down in the new Energy Industry Act. Regardless of this, electricity meters that do not comply with the Weights and Measures Act may not be used to measure the electricity energy that has been sold.

3 National Approach to Standardisation of Electromobility

The market introduction of electromobility is a particular challenge and opportunity for Germany. The sectors of automobile technology, information and communication technology (ICT) as well as electrical engineering/ electrical technology were established at a high level of quality, safety and availability and will partly merge in future. The remainder of this section will describe the motivation for the preparation of the German Standardisation Roadmap for Electromobility, the benefits for individual groups interested in electromobility and the national and international coordination of electromobility.

The present German Standardisation Roadmap for Electromobility frequently uses terms with special meaning for this field. Terms and abbreviations are listed in Annex B in order to create a common foundation for the discussion of electromobility standardisation.

3.1 Reasons and conditions behind the development of the German Standardisation Roadmap for Electromobility

Standardisation is a central factor for disseminating electromobility, in addition to road vehicle engineering, energy supply, and the associated information and communication technologies.

The automotive engineering, electrical engineering/energy technology and information and communication technology (ICT) domains, which up to now have largely been considered separately, need to converge if electromobility is to be a success. A long-term strategy has to be developed for this purpose that takes national interests into consideration while at the same time giving German industry access to the expanding international market. In this context, the German Federal Government founded the National Platform for Electromobility (NPE) in May 2010, which acts as a consulting group. The working group 4 "Standardisation, specification and certification" (AG 4) of the NPE is responsible for the standardisation strategy developed by the DKE/EMOBILITY.30 group in the form of the German Standardisation Roadmap for Electromobility. The German Standardisation Roadmap for Electromobility embraces immediate standardisation needs at one end of the scale and long-term standardisation activities at the other, as well as the need for research.

General suggestion

A larger number of necessary standards already exists in the established sectors of automobile technology and electrotechnology. They must be utilised and publicised accordingly. Information about these standardisation works and their status are part of the German Standardisation Roadmap for Electrotechnology. Furthermore, the focus of the required work is less on the initiation of new standards projects but rather on the expansion or adaptation of existing standards to the requirements of electromobility. An interdisciplinary collaboration at an international level is especially important for interdisciplinary topics.

System components, domains and subsectors relating to electromobility standardisation are shown in Figure 4. Because of its great significance, battery technology is dealt with in a separate chapter of the German Standardisation Roadmap for Electromobility. Product safety and communication are cross-cutting topics which affect all system components. Standardisation requirements can be divided into these main areas.

Communications and energy flow		
Interfaces		
Protocols		
Information safety and data security		
Automobile engineering		**Charging infrastructure**
Power electronics	**Energy storage or sources**	Connector technology
Auxiliary components	Li+ batteries	Power electronics
On-board wiring	Fuel cells	Communication and control technology
Drive	Capacitors	
Product and operating safety		
Functional safety		
Electrical safety		

Figure 4: System components and domains relevant for standardisation

A look at the stakeholders involved shows that the convergence of automotive technology and electrical engineering/energy technology has top priority for the market introduction of electromobility. Therefore, the various stakeholders can be generally assigned either to the “vehicle” or the “charging infrastructure” domain, as shown in Figure 5. In this figure the battery is depicted as a separate component, since it can be assumed that this branch of industry will play a particularly significant role, and services dealing specifically with batteries will emerge.

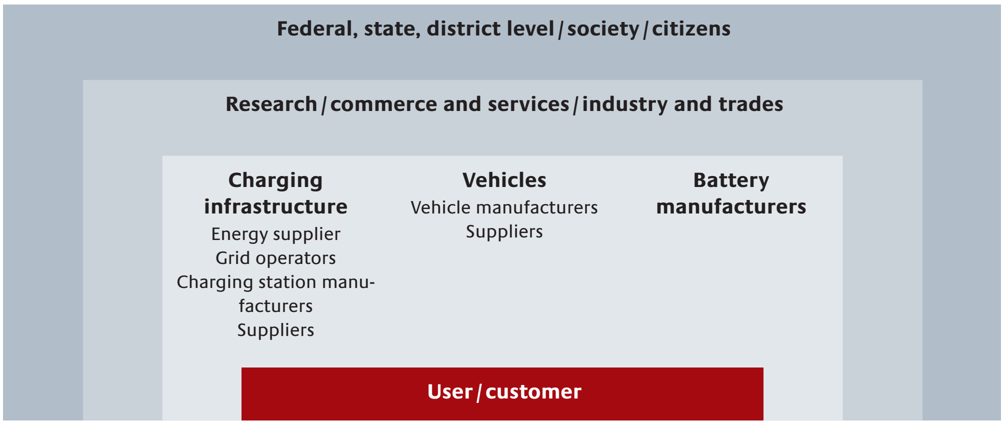


Figure 5: Electromobility stakeholders

In the services sector, established fields of activity will remain and new ones will emerge. This sector is closely linked with the development of new business models which are not, however, the main focus of phase 1 of electromobility standardisation. Some examples of existing service providers and new ones which may emerge are listed below:

- vehicle sales
- vehicle and battery financing (rental, leasing)
- inspection, certification
- communication services (Internet, mobile telephony, etc.)
- electricity traders
- charging station operators
- parking space management (parking and battery-charging)
- billing/payment and arbitration services (clearing, roaming)
- meter service providers and meter operators.

The benefits of the German Standardisation Roadmap for Electromobility and the reasons for its development are explained in the following chapter. Various system approaches and the background for creating this document are explained in more detail in chapter 4. The general need for standardisation from the point of view of German industry is set out in the German Standardisation Strategy [2][3].

3.2 Benefits of electromobility and its standardisation

Electromobility will be a major field of innovation throughout the coming decades. Ensuring sustainable mobility is one of the prerequisites for economic growth, and the transport and automobile industries are still major industrial sectors of enormous relevance to employment in Germany. We can expect to see the emergence of new business relationships and added value areas as electromobility spreads. Various stakeholders stand to benefit from electromobility and its standardisation in different ways and to varying extents. This chapter describes the overall advantages of standardisation for the market introduction of electromobility. The benefits of electromobility and its standardisation for various stakeholders are described in more detail in Annex C.

Standards and specifications prepare markets
To ensure a broad dissemination of electromobility, individual mobility must remain at the level enjoyed today. This means people should be able to use their own vehicles throughout Europe, at least, and must be able to purchase and operate vehicles at acceptable prices. Furthermore, new electric vehicles must offer the same level of safety and reliability as comparable conventional vehicles.

Standardisation has a pioneering effect, particularly where the following aspects are involved:

- Charging the vehicle requires suitable infrastructure.
- To facilitate unrestricted mobility in Europe, the goal should be to ensure that the charging infrastructure (including payment/billing systems) and different makes of vehicles are compatible.
- The cost of system components (vehicles and charging infrastructure) is a decisive factor for acceptance by vehicle manufacturers and consumers, and therefore for marketability.
- These costs can be reduced not only through innovation, but also to a large extent by greater production quantities. The division of labour among component manufacturers associated with this will only be possible if interfaces to individual components are defined and standardised.
- Safety for users, operators and the infrastructure must be ensured by means of generally accepted rules and test methods, and it must be possible to prove conformity by objective means.

Standards and specifications support innovation
The development and implementation of electromobility is a continental-scale project requiring large investments. The framework conditions must be set down in standards and specifications to provide an acceptable level of investment security.

The degree of detail needs to be determined individually for each standard or specification. The aim is to find an optimal solution somewhere between general guidelines and specific requirements.

General suggestion

In order to promote innovation, standardisation must relate to functionality and provisions regarding technical solutions must be avoided ("performance-based rather than descriptive"). Every standard/specification should be as "open" as possible, providing enough room to describe the general purpose, while leaving enough freedom for innovative solutions that enable differentiated competition. The aim is to strive for the greatest possible security for the future, because specifications that are too detailed make future improvements difficult or even impossible. However, technical solutions must be specified for interface standards (e.g. between the vehicle and power grid) if reasonable and required to ensure interoperability.

To take this aspect into account, there are a number of different types of standards which can provide the desired framework. These include:

- operating performance standards,
- test standards,
- interface standards / compatibility standards,
- terminology standards, and
- product standards.

Standardisation accelerates development

In view of the considerable effort still needed, a general framework needs to be defined as quickly as possible. Standards and specifications having an "enabler" function must be developed rapidly. This requires standardisation at the R&D phase. Specifications functioning as forerunners to standards can be drawn up within a short amount of time. Also, the "normative power of established facts" is another factor that helps accelerate procedures. Technical solutions which assert themselves on the market sustainably should be described in specifications and standards without delay. Individual patent rights should be avoided in standards or at least be made available under FRAND ("fair, reasonable and non-discriminatory") terms.

Reorganising the energy system to accommodate a greater use of renewable energy sources, whose generation can fluctuate strongly, requires intelligent generation systems, grids and loads, the so-called "smart grid", and requires sufficient capacities for the intermediate storage of energy generated from renewable sources. This also includes the charging process for electric vehicles, which provides the technical potential for supporting the integration of renewable energy sources (when charging and, in the future, for V2G feedback into the grid). This requires technical solutions extending beyond simple connection and charging. In these small, distributed systems, it is difficult to find a sustainable technical and commercial solution without appropriate standardisation.

3.3 National agreement on electromobility

A close coordination of research & development, regulation and statutory framework conditions with standardisation is necessary for the national agreement on electromobility. National standardisation and regulation in individual countries must not prevent international harmonisation. Increased collaboration at a national and international level is required to actively influence and implement the goals of electromobility. Therefore, German companies and R&D institutions (including universities) must get more involved in German, European and international standardisation work. The latter must be regarded as an integral part of R&D projects and are therefore eligible for funding.

General suggestion

3.3.1 Joint activities by the DKE, DIN and NAAutomobil

Electromobility is shaped by many actors and specialist areas. Therefore, collaboration across groups and coordination at a national level to steer standardisation activities and to avoid duplicate work in the field of electromobility (cf. Figure 6). The EMOBILITY steering group (joint body of the DKE and DIN NAAutomobil) was set up to coordinate activities in the electrical and automotive industries. The work of this group is supported by the DIN Electromobility Office.

General suggestion

The aim of the EMOBILITY steering group is to coordinate various standardisation and specification projects and to ensure a continual flow of information – to do this, the steering group needs to have sufficient powers of authority. Other focal tasks of the steering group are the internationalisation of standardisation in this area and the avoidance of isolated national solutions which would impede the international and, above

General suggestion (continued)	all, cost-efficient introduction of electromobility and lead to new trade barriers. Issues concerning automobiles are dealt with by DIN/NAAutomobil, while infrastructure issues are dealt with by the DKE, with the EMOBILITY steering group serving as the interface between the two. Instead of creating new bodies, the existing committees within DIN and the DKE should be strengthened.

The EMOBILITY steering group is made up of representatives from companies and associations active in the fields of electrical/electronic components, power generation and supply, as well as automobile manufacturers and suppliers, and testing institutes. The electrical trade is represented by the German Association of Electrical and IT Trades (ZVEH) as a future partner in developing the infrastructure.

DIN has set up an "Electromobility Office" to support the work of NAAutomobil, the DKE, and the EMOBILITY steering group. This body serves as a central, neutral contact point not only for established organisations, but above all for those who have not been much involved in standardisation work up to now, for instance those in research and development. Another important task is the continual analysis and coordination of relevant activities in standardisation and specification, and the continuous development of networks at a European and international level. The Electromobility Office provides feedback to the DKE, NAAutomobil and the steering group on relevant topics, taking all approaches and developments into consideration as much as possible.

For national standardisation work, NAAutomobil and the DKE have established joint bodies to deal with topics relating to the vehicle-infrastructure interface (cf. Figure 6).

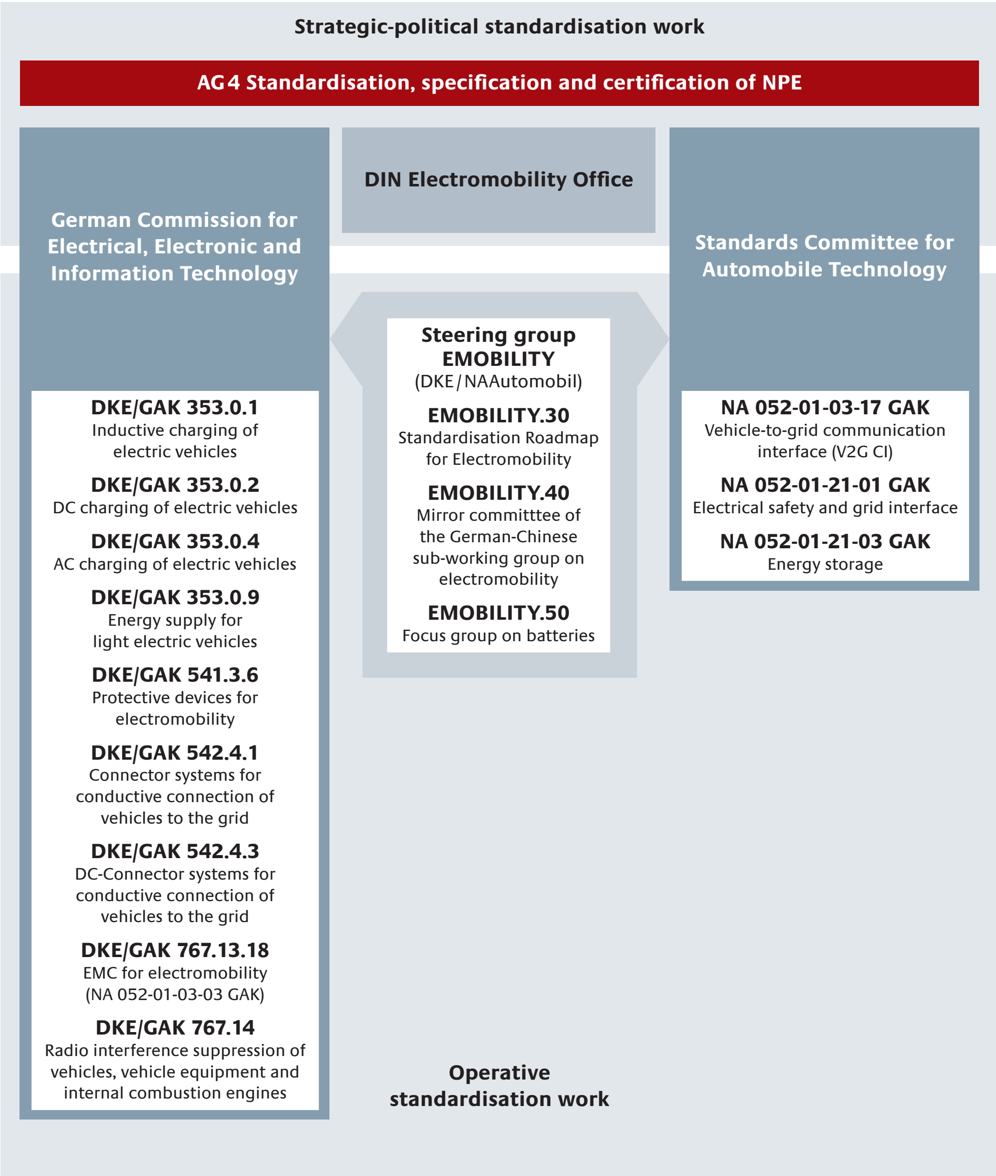


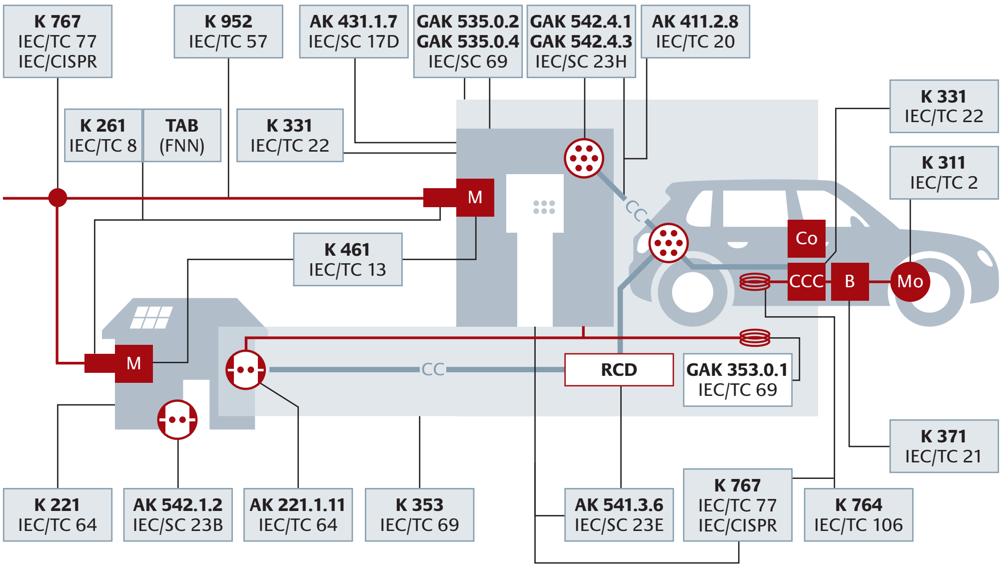
Figure 6: National coordination of electromobility standardisation and the joint DKE/DIN bodies involved (overview)

3.3.2 Activities at the DKE

In addition to the aforementioned EMOBILITY steering group, whose purpose is the coordination of activities between VDE/DKE and VDA/NAAutomobil, there are numerous other DKE bodies which are involved in electromobility standardisation. Figure 7 provides a detailed overview of the bodies active in each area.

DKE/STD 1911.5 deals with the standardisation of integration of electromobility into the smart grid. As such it is the organisational interface between electromobility standardisation and smart grid standardisation.

A comprehensive overview of the relevant committees is given in Annex D.2.



B	Battery / fuel cell	CCC	Charger current converter / power electronics
Co	Communication (PWM; V2G)	Mo	Motor
CC	Charger cable	RCD	Residual current protective device (ground leakage breaker)
	Component	M	Meter
	Electrical connection		Explanation

Figure 7: Overview of relevant bodies active in the field of electromobility

3.3.3 Activities of NAAutomobil

Numerous bodies of NAAutomobil deal with the standardisation of electrical and electronic components and systems, and with the specification of issues applicable to electric vehicles. Figure 8 shows an overview of these bodies. A comprehensive overview is given in Annex D.2.

AA-03 "Electrical equipment"	AA-21 "Electric road vehicles"	AA-26 "Functional safety"
Data communication NA 052-01-03-01 AK	**Electrical safety and grid interface** NA 052-01-21-01 GAK	**General requirements for road vehicles** NA 052-01-26-01 AK
EMC NA 052-01-03-03 GAK	**Power and consumption measurement** NA 052-01-21-02 AK	
Cables for electric vehicles NA 052-01-03-04 AK	**Energy storage** NA 052-01-21-03 GAK	
Fuses NA 052-01-03-05 AK	**Vehicle systems for electric drive** NA 052-01-21-04 AK	
Plug connectors NA 052-01-03-06 AK	**Wireless charging** NA 052-01-21-05 AK	
Environmental conditions NA 052-01-03-13 AK		
Vehicle-to-grid communication NA 052-01-03-17 AK		

Figure 8: Overview of relevant bodies of NAAutomobil dealing with electromobility

3.3.4 Standardisation activities on data security and data privacy

DKE/AK 952.0.15, which is responsible for IT security issues, works in close cooperation with DKE/UK 931.1, the body responsible for IT security in process automation, as well as with VDE ETG/ITG AG IT security and the responsible working group in the Forum Network Technology/Network Operation in VDE (FNN). It mirrors the work carried out on the IEC 62351 series of standards by IEC/TC 57/WG 15, and has initiated work on Part 8 of this series dealing with role-based access control. This body also supports all activities aiming to bring IT security standardisation in DKE Division 9 under the auspices of one body as far as possible. DKE/AK 952.0.15 has supported work within the German Federal Office of Information Security (BSI) on a Common Criteria Protection Profile for smart meters and the corresponding gateways.

The cross-sectional group DKE/STD 1911.11.5 was founded in 2014. It deals with information security and data privacy in the smart grid, in cooperation with the appropriate bodies on smart meters, with experts in IT security in network control technology within DIN NIA 27.

3.3.5 Standardisation activities carried out within funded projects

There are currently a number of pilot and model projects being carried out in Germany. The main objective of these activities is to gather experience and gain new insights in the practical implementation of electromobility. Another major topic being dealt with in these projects and in exchanges of experience is the extent to which existing standards/specifications are to be taken into consideration and/or revised and where new standards and specifications are needed. The findings need to be analysed and assessed for their relevance to standardisation on the basis of the time schedule for each project. Projects include those funded by the German Federal Government (i.e. by the ministries BMBF, BMU, BMVBS, BMWi), and those initiated by the German federal states (e.g. Auto-Cluster.NRW, Eco Fleet Hamburg, the four showcases of electromobility).

Several of these projects have a clear relationship to standardisation. These are, for example:

- The programme "Innovation with Standards" (INS) initiated by the Federal Ministry of Economics and Technology (BMWi), which supports innovative standardisation projects of German businesses in order to better uphold their interests at a national and international level. In addition to electromobility, this programme also covers other areas of the high-tech strategy of the German Government and especially addresses small and medium-sized businesses (project duration until 12/2015).
- The project "Electromobility – Implementation of the Standardisation Roadmap" funded by the BMWi. Its main focus is the targeted implementation of individual standardisation topics identified based on the German Standardisation Roadmap for Electromobility or, for example, in ongoing research and development projects. The objective of this project is to strengthen Germany's pioneering role in setting standards, which is to be implemented with targeted activities and the support of the German industry and research institutions, especially with respect to activities at European and international standardisation organisations. For this purpose, interested groups from the economic and research field are involved. A special focus lies on small and medium-sized businesses (KMU) (project duration until 09/2015).
- The technology competition "ICT for Electromobility II: Smart Car – Smart Grid – Smart Traffic" started by the BMWi in spring 2011. The focus of "ICT for Electromobility II" lies on promoting research, development and pilot tests in order to more quickly develop concepts based on information and communication technology and make them available to the public. Currently, 18 projects were selected for funding as part of the technology competition. The project "Systematic integration of electromobility – analyses of practical applications and user stories" is funded in addition to the model projects, where user stories and use cases specific to electromobility are developed. We expect from this use case method, which is now widely used, to systematically identify gaps and demands for further development and to then work on them. Thus, innovation barriers will be identified and overcome, and systematic approaches and collaboration is promoted across projects (project duration until 10/2015).

The DKE has been a major player in the development in the application of use cases for the technology-independent description of processes for standardisation purposes as part of its work on smart grids (DKE/STD 1911.0.2). The work group DKE.AK STD 1113.0.3 "Use-cases for e-mobility" is responsible for uses cases specific to electromobility.

A use case describes processes in terms of the market roles involved and abstracts technical details. Defining the actors, allocating the respective roles, describing the activities and delimiting the system are some of the important tasks that have a significant effect on the structure of a use case. In this way the use cases method shows how a process is logically divided into its individual steps. A use case diagram describes the user's needs for a clearly delimited process and helps define interfaces.

The work of the standardisation bodies consists of determining the technical requirements for their own area from the appropriate use cases and transposing these into standards. Thus, use cases can represent processes at an early stage and describe plans which still have to be implemented systemically.

3.4 International agreement on electromobility

General suggestion

Currently, national and international standardisation concepts are in competition with each other. Electromobility can only be successful if there are sufficient international standards and specifications on this topic. This applies in the same way to the interface of vehicle and infrastructure. A single German or European standardisation for electromobility is seen as insufficient. To accelerate international standardisation, nationally developed suggestions and results obtained in Germany could be used for implementation. Internationally harmonised standards ensure success and provide industry with the same conditions for all markets.

International electrotechnical standardisation is carried out at IEC, while these activities in the automotive sector are carried out at ISO. Before electromobility can be introduced, work within these two organisations needs to be harmonised. The coordination of ISO and IEC activities is essential in order to avoid duplication of work and to ensure the participation of all experts from the economic sectors involved in electromobility, for example in the development of standards and specifications for vehicle-to-grid interfaces. In March 2011, ISO and IEC signed a Memorandum of Understanding (MoU) which primarily covers the establishment of joint working groups (JWGs) under mode 5 to deal with all aspects of the vehicle-to-grid interface.

General suggestion

The adopted MoU needs to be continuously implemented. The secretariats and chairpersons of the respective bodies must continue to ensure the implementation in ongoing reciprocal consultations, especially for new projects.

Consortia, especially SAE, must be requested to get involved in standardisation work at ISO and IEC instead of developing their own additional specifications. It can be assumed that the SEA standards are a binding regulation for many states of the USA. Including contents of SAE standards in international, consensus-based standards (ISO, IEC) is difficult due to copyright issues (e.g. SAE J 2929). However, the objective must be to harmonise contents of SAE standards with contents of ISO and EIC standards. This is the only possibility to reduce licensing work for the automobile industry in the USA. In the meantime, we recommend that representatives of the European industry be involved in the work of SAE bodies in order to avoid deviating regulations and that possibilities of a bilateral collaboration for the development of common specifications are used before ISO/IEC standardisation.

Furthermore, it cannot be expected currently that national Chinese standards for electric vehicles can become international standards. However, it is likely that fulfilling these standards is a condition for market access in China. Translation and interpretation of Chinese standards is often problematic. Germany strongly promoted an increased involvement of China in international standardisation in the German-Chinese Economic Committee and with standardisation. Future developments on this issue are awaited.

Moreover, there are a number of other organisations that generally influence requirements for electric vehicles and electromobility due to their activities. Thus, they influence standards directly or indirectly. It must be reviewed whether and how coordination of activities is necessary, and especially to which extent activities of other organisations can be included in ISO and IEC.

The EMOBILITY steering group and the DIN electromobility office should coordinate a suitable procedure for liaising with other organisations. Other organisations must be identified early and the establishing of conflicting requirements for electromobility must be avoided through early contacts and involvement of these organisations. An involvement in standardisation organisations other than ISO and IEC must only be a temporary option.

3.5 CEN/CENELEC eMobility Coordination Group (eM-CG), EU mandate M/468

The European Commission has recognised the significance of electromobility in achieving climate protection targets and as an economic factor for Europe, emphasising this by issuing standardisation mandate M/468. It aims at ensuring uniform charging methods for electric vehicles throughout the European Union and avoiding isolated solutions by individual European member states. The mandate focuses on the urgent topic of creating standards and specifications for uniform charging interfaces between the vehicle and the power supply grid. The controversial debates currently taking place at a European level, particularly with reference to the design of the vehicle-to-grid interface, clearly shows that agreement is imperative. The mandate not only covers passenger cars, but also other vehicle categories, e.g. scooters.

The standardisation mandate was handed over to representatives of the European standards organisations CEN, CENELEC and ETSI in June 2010. CEN and CENELEC have adopted the mandate and have already set up the joint CEN/CENELEC focus group on European electromobility. This focus group examined the requirements and preconditions within each European country for a uniform charging structure, as well as the need for the standardisation of electromobility in Europe. In October 2011, the report "Standardisation for road vehicles and associated infrastructure" was published. The CEN/CENELEC focus group on European electromobility recommends founding a CEN/CENELEC eMobility Coordination Group (eM-CG) in order to support standardisation activities during the important phase of preparing new or updating existing standards. The eM CG ensures that the relevant technical institutions implement and maintain the standards required for the electromobility sector accordingly.

Due to the position taken by a few manufacturers and users of certain plug and socket configurations, it was not possible to issue a consensus-based recommendation for a uniform pan-European plug and socket system, even though a large majority of the interest groups supported the German plug type 2 proposal. In January 2013, the European Commission presented a suggestion for a regulation on alternative fuels and recommended the use of plug type 2/combo 2 for Europe. This suggestion was confirmed by the EU Parliament in April 2014.

The EU Commission has a draft for a new standardisation mandate to implement this regulation. In this context, political support continues to be imperative in order to promote the interests for German industry.

3.6 Other relevant sources of information

A number of sources were consulted during the development of the German Standardisation Roadmap for Electromobility. Relevant information in these sources was analysed and integrated into the German Standardisation Roadmap for Electromobility. The following studies were especially important:

- **DIN study "Normungsbedarf für alternative Antriebe & Elektromobilität" (Need for the standardisation for alternative drive and electromobility), carried out under the leadership of NAAutomobil [4]**
  This DIN study identifies and provides an overview of the relevant standards in the field of electromobility, including existing standards and standards which were still under development at the time the study was concluded. In addition, the study includes a number of recommendations which should be taken into account in the revision of the German Standardisation Roadmap for Electromobility.
- **VDE study on electric vehicles [5]**
  This VDE study illustrates the potential for battery-powered electric vehicles and evaluates the technical feasibility of individual components while determining the need for R&D activities. With regard to the connection of vehicles to the supply grid, scenarios for the introduction of one million electric vehicles or more are described. The introduction of one million electric vehicles and more is described in scenarios for the connection of vehicles to the supply grid. The study also evaluates technical aspects of the main components of electric vehicles under technical considerations. In addition to the key components of the drive train, it also examines auxiliary power supply, chargers, accessories and range extenders.
- **VDE study "E-Mobility 2020: Technologien – Infrastruktur – Märkte" (E-mobility 2020: Technologies – Infrastructure – Markets) [14]**
  In the study "E-mobility 2020: Technologies – Infrastructure – Markets", member companies and universities assessed Germany's current technological position, and the opportunities for and challenges facing electromobility in Germany. In addition, around 1,000 consumers were interviewed. Their answers provide information on the general attitude towards and acceptance of electromobility among the public.

- **Livre Vert [12]**
  The French “Livre Vert sur les infrastructures de recharge ouvertes au public pour les véhicules «décarbonés»” (Green paper on public charging infrastructures for zero emission vehicles) provides a guide for regional authorities who intend to implement projects for setting up a public charging infrastructure. It was commissioned by the French government under the chairmanship of the Senator of the Département Alpes-Maritimes in cooperation with representatives of politics and technology divisions in the regional authorities of 13 pilot regions, as well as with automobile manufacturers, companies and associations in the energy supply, transportation, construction and infrastructure sectors, along with public authorities, institutes and agencies involved in energy, industry, environment and finance. The study was published in April 2011.
- **ANSI EVSP**
  The US-American standardisation organisation ANSI coordinates the development of the Standardisation Roadmap ANSI EVSP. Version 2 of the ANSI Standardisation Roadmap was published in May 2013 and was available in English in addition to the German Roadmap, the CEN/CENELEC Roadmap and the ACEA recommendations.
- **ACEA position paper [13]**
  The ACEA (European Automobile Manufacturers Association) has agreed on the use of uniform standards for the charging of electric vehicles. From 2017 onwards, there is to be a uniform plug (type 2) for all electric vehicles. Japanese and South Korean automobile manufacturers participated in the discussions.

In the automotive sector there are numerous organisations whose activities influence the requirements on electric vehicles and who therefore have a direct or indirect influence on standards and specifications. Furthermore, standardisation of the Internet needs to be taken into consideration, since it is expected that web-based communications will play a role in electromobility. In this context, the following are to be mentioned:

- **Euro NCAP, US NCAP**
  Test protocols and procedures for evaluating the active and passive safety of vehicles – particularly category M1 passenger vehicles – are not standards in the real sense. Nevertheless, they define performance requirements which have a great influence on vehicle design.
- **ETSI TC ITS / CAR 2 CAR Communication Consortium**
  Under European standardisation mandate M/453, ETSI is working in close cooperation with the CAR 2 CAR Communication Consortium on standardising a short-range vehicle-vehicle and vehicle-infrastructure communication based on the IEEE 802.11p standards. In this context, the possibility of communication with electric charging stations is being discussed.
- **World Wide Web Consortium (W3C)**
  The World Wide Web Consortium (W3C) is the body for standardising technologies concerning the World Wide Web. W3C is not an internationally recognised organisation and is therefore not entitled to lay down standards. Nevertheless, W3C specifications, such as XML, form the basis for several ISO standards. Specifications laid down by W3C affect the communications and data security sectors.

4 Overview of the “Electromobility” System

This section describes electromobility system approaches which, according to experts from German industry, research and politics, will make a major contribution towards achieving the goals of phase 1 (one million electric vehicles on Germany’s roads by 2020). The technologies and stakeholders involved were identified in section 3.1. The present section begins by presenting use case scenarios for electric vehicles and then describes the energy and data flows involved. This is followed by a more detailed discussion of the vehicle, energy storage and charging infrastructure domains. For each domain, the relevant national and international standards and specifications are named which have been identified in current studies carried out by manufacturers, users and researchers active in the electromobility sector.

4.1 Electric vehicles and the smart grid

Electromobility offers the unique opportunity of combining the advantages of environmentally-friendly mobility with an efficient, optimised utilisation of electricity supply grid resources and sustainably generated electrical energy. This gives rise to a number of special requirements, particularly on the technology used and on the standardisation of the interface between electric vehicles and the grid.

The development of standards is a fundamental prerequisite because there are so many different use cases for the battery charging process. The following use cases, in particular, can be identified:

- Charging
  - Charging locations
    - Private (e.g. garage), semi-private (e.g. company yard), public or semi-public (e.g. supermarket car park) charging station
    - In combination with parking
    - Outdoors, under a roof or in an enclosed space
    - At a single-phase household mains outlet, at a friend's or relative's house
    - While travelling (fast charging)
  - Charging functions
    - Normal charging as AC or DC charging with power up to 22 kW ("normal charging": in the following "normal charging" is used as opposed to fast charging)
    - Fast charging as AC or DC charging with power of more than 22 kW
    - cable-bound or inductive
    - With or without communications path for individual billing
    - With or without communications path for negotiating electricity rates
    - With or without load management/power grid services (local, smart grid)
    - Grid feedback option (phase 2)
    - Metering
  - Vehicle functions while connected to the stationary grid
    - Charging process monitoring
    - Temperature control of battery and/or the vehicle interior while vehicle is stationary

- Billing/payment
  - Without separate billing (billing as part of the "normal" electricity bill)
  - With a separate cumulative bill (separate meter)
  - With a separate detailed bill (comparable to a "fuel card")
  - With direct payment (cash, electronic, possibly integrated into parking space management)
  - Direct or indirect connection of the vehicle to the billing system

This list provides some idea of the complexity of the issues involved in the charging process. In addition to new standards projects dealing with these issues, there will be a need to review and, where necessary, adapt existing vehicle standards in the fields of

- electrical safety
- electromagnetic compliance (EMC)
- the requirements on various electrical/electronic systems and components.

Furthermore, from the viewpoint of energy suppliers and grid operators, the system must be linked to the smart grid. As a result, other load scenarios including energy feedback will evolve in addition to the conventional “charging” scenario. Other forms are imaginable between these scenarios, as the examples in Figure 9 show.

	Charging	Price management	Load management	V2G feedback
Customer	chooses time and charging profile	chooses suitable time for charging based on time-based tariff schemes	specifies desired usage (how much charge is required by when)	specifies desired usage (how much charge is required by when)
Charging infra-structure provider	has no influence on or cannot switch off when smart meters are used	has indirect influence on charging behaviour due to variable pricing scheme	can actively adapt load to the currently available energy supply	can actively control load and energy feedback

Figure 9: Forms of grid integration of electric vehicles during charging

This table shows an increasingly close integration of the electric vehicle into the smart grid from left to right and ways of providing the respective grid services. In terms of systems theory, each of these variants represents a control loop for optimising consumption and the feedback of energy into the grid. With the “price management” method, the current electricity price is the control parameter for consumption, whereas the “load management” and “feedback” methods make precise control of the charging process possible.

Other use case scenarios which are not directly associated with the charging process have also been discussed in connection with the German Standardisation Roadmap for Electromobility. Examples of these are:

- stationary vehicle
- vehicle in motion
- service (diagnosis, maintenance and repairs)
- accidents, recovery of vehicle after an accident
- towing
- decommissioning, recycling

These scenarios will be discussed as the need arises.

4.2 Interfaces, energy flows and communications

The introduction of electromobility will lead to a need for many new energy flow and communication relationships and protocols, and will require the adaptation of existing interfaces. The following interfaces are conceivable and need to be taken into consideration:

- vehicle – charging infrastructure
- vehicle – user
- vehicle – energy trade
- charging infrastructure – grid
- charging infrastructure – energy trade
- charging infrastructure – charging infrastructure operators
- charging infrastructure operators – billing and payment services
- users – billing and payment services
- users – charging infrastructure (e.g. reservation of publicly available charging stations)
- charging infrastructure operators – users
- vehicle – service
- vehicle – billing and payment services

In some cases, both data and energy are transmitted via these interfaces. The various abstraction levels of the interfaces can be represented as a simple layer model, as shown in Figure 10.

Services	
Metering	
Billing / payment	
Diagnosis	
Load management	
Feedback management	
Communication	**Energy flows**
Communication media	Direction
Communication protocols	Protection conditions
Signalling	
Physical level	
Electrical parameters	
Mechanical parameters	
Transmission medium (conductive, inductive)	

Figure 10: Abstraction levels of electromobility interfaces

The communications layer can be subdivided into fundamental signalling (required to ensure safety), more complex communication protocols (e.g. for billing applications), and communication media (e.g. powerline).

The following sections identify the individual aspects of energy flows and interfaces, the current state of standardisation, as well as what remains to be done.

4.2.1 Energy flows

A significant number of national and international standardisation activities deal with defining the characteristic parameters of possible energy flows. The first type of flow that may be considered is the (conductive) charging of a vehicle battery via a cable and mains outlet. However, other energy flows are already being looked at within the electromobility framework, as shown in Figure 11, such as inductive charging, battery switching and charging by electrolyte exchange (“redox flow”). Other energy flow modes are not regarded as being practicable at present or are irrelevant for standardisation (e.g. solar-powered cars parked under a street light).

At present, there is no international approach to the standardisation of battery switching systems. Research still has to be carried out on redox-flow charging systems before the main characteristic parameters can be defined in standards.

IEC is developing the standard collection IEC 61980-1 on inductive charging. Since conductive charging will be of prime importance in phase 1 of the electromobility campaign, electromobility standardisation activities in this domain are the most advanced. Thus, the standardisation activities are most advanced in this area.

	Form of energy transmission	Direction of energy flow	
Grid	Charger cable	→ ⇠	Vehicle
	Induction	→ ⇠	
	Redox flow	→	
	Battery replacement	→	

Figure 11: Possible electromobility energy flows

Standardisation activities dealing with energy flows for conductive charging focus on mechanical and electrical parameters and on signalling. The IEC 62196 series is of prime interest in this context. Section 4.4 discusses details of various charging modes and system approaches to energy flows as proposed in the IEC 61851 series.

4.2.2 Communication

Communication between the vehicle and the charging infrastructure (vehicle-to-grid communication interface, V2G CI) has top priority in standardisation.

General suggestion

For the smart grid, the communication (except for specific data content) of a charging station (with a chargeable vehicle) should not be dealt with differently compared to a connected consumer/generator. The communication of the charging station must be compatible with other forms of communication in the smart grid. Furthermore, energy management of the electric vehicle (EV) must support the cooperation of EV and the smart grid. Thus, it is recommended to follow and adopt the respective developments (e.g. in DKE/K STD 1911 steering group “Standardisation of e-energy/smart grids” with a focus on “Grid integration of electromobility”, and the international smart grid [standardisation] bodies).

The standardisation activities of the smart grid must be intensified since the electric vehicle will be a considerable addition as relevant consumer. Based on this, a close connection with the Standardisation Roadmap for Smart Grids [10] is necessary.

The chronological development of the smart grid must be adjusted according to the requirements for electromobility; a collaboration of the standardisation bodies for the smart grid and electromobility must be sought. During the starting phase (low number of vehicles) with a relatively low charging load, no electricity shortages are expected. However, there will be a demand for intelligent charging and load management in the medium-term when the number of vehicles increases.

Suggestion 4.2.2.1

In one of the first stages of load management, it is expected that the user will have the option to select the charging duration as well as the charging level depending on the price. Price formation at the beginning of the charging process could be possible, depending on the predictions for energy supply and demand within the next number of hours. This is semi-statistical load management from the user’s point of view with a temporal dynamic nature within a duration of hours. Suitable application and communication protocols must be standardised.

Dynamic load management includes the possibility to dynamically (e.g. within minutes) adjust the charging capacity to the current capacity supply (e.g. renewable energy) during the charging process. This use case has an increased temporal dynamic and requires suitable communication protocols that have to be defined.

The integration of existing installations must be considered regarding implementation. A minimum demand on the voltage quality which has to be available during charging and needs to be defined is a condition for static and dynamic load management.

Grid re-generation with the simultaneous switching on of loads is a critical point in time after a power failure. Suitable mechanisms for controlled (e.g. randomly delayed) resumption of load must be defined and standardised in order to avoid a large number of vehicles being charged, causing grid instabilities.

Suggestion 4.2.2.1 (continued)

For the user, mechanisms must be defined for all charging operating modes for an automatic resumption of the charging process.

In particular, possible damage to the customer’s device must be avoided. The operator of a station should implement measures to avoid damage according to DIN VDE 0100-450.

This results in the necessity to design the communication “vehicle – charging column” and “charging column – infrastructure” continuously. The communication between the vehicle and the infrastructure is described in ISO/TC 22/SC 3 JWG. The documents ISO 15118-1 “Road vehicles – Vehicle to grid communication interface – Part 1: General information and use case definition” and ISO 15118-2 “Road vehicles – Vehicle to grid communication interface – Part 2: Network and application protocol requirements” are published as an international standard (IS). The document ISO 15118-3 “Road vehicles – Vehicle to grid communication interface – Part 3: Physical and data link layer requirements” was adopted as a Final Draft International Standard (FDIS) and will be published shortly. Works on the document ISO 1158-6, -7 and -8 as well as the project ETSI DTS/ITS-0010031 specifying the wireless communication to support inductive and conductive charging of the electric vehicle are to be followed and will be concluded quickly. Requirements on the distribution grids must be adapted for the charging interface (IEC 61851).

The currently preferred solution for the physical layer for a communications interface between the charging station and the vehicle is HomePlug GreenPhy, which is a powerline communications system. This type of communication is downwardly compatible and can be used with the plug and socket systems currently being standardised without requiring dedicated communication contacts. Furthermore, IP and XML-based technologies, in particular, are being used for the higher layers, and it is widely assumed that the charging infrastructure will act as a gateway. Also being discussed are solutions for the association problem between current and communication flow.

Operators will have to define the “charging station – charging infrastructure operators” communications interface if charging stations are to be operated as free-standing stations. In terms of energy management, the integration of private charging stations into building automation systems is conceivable. ISO/IEC 14534-3 “Information technology – Home Electronic Systems (HES)” (ISO/IEC JTC 1/SC 25) is a current standard that provides a basis for applications in both residential and non-residential buildings.

Due to the high energy demand of electromobility in comparison to household demand and due to the possibility of feeding energy back into the grid in future, further higher-level integration of the charging stations into the smart grid seems more practical. IEC 61850-420 would be appropriate for this purpose. Some application-specific details still have to be included, e.g. which parameters need to be controlled and/or reported.

In addition to communication between the vehicle and charging infrastructure (V2G CI), new business models require an integration of electric vehicles into the information systems and infrastructures of third-party providers. This requires an exchange of operation-specific vehicle data with these systems, which can be achieved with vehicle internal systems and information systems as well as service-based information systems for the fleet management of vehicles. The implementation of business models can be realised with standardised interfaces between the vehicle and the integrating information system of a third-party provider or between a service-based information system and further processing applications. The cooperation of vehicle manufacturers, standardisation bodies and developers of information systems is recommended in this case in order to promote the implementation of electromobility-specific business models and to minimise the technological barriers of market launch.

It is recommended to find a national consensus on standardised interfaces and the data to be transmitted under the leadership of NPE AG 4. **Suggestion 4.2.2.2**

4.2.3 Services

Authorisation
The process of authorising the user at a charging station can be done in several ways. The ISO 15118 series describes authorisation using the communication specified there. Another option for authorisation are so-called “smart cards” (RFID technology). For this purpose, IEC started the project IEC 62831 “User identification in electric vehicle service equipment using a smartcard”. This standard will describe the following requirements.

1. Process of initialising the communication between the charging station and smart card
2. Encryption for secure data exchange
3. Information to be sent: card ID and service provider ID
4. Data exchange protocol

The standard is developed based on the published RFID standards such as ISO/IEC 14443 and ISO/IEC 7816.

Metering
Supplied energy is billed on the basis of the measured energy consumed by the customer in accordance with the applicable legal provisions, primarily laws on weights and measures. While energy consumption during AC charging is measured using standardised and calibrated meters, the measurement of energy used for DC and inductive charging has not yet been standardised.

Currently, there are no economically applicable and also calibration-conforming metering methods for DC charging. However, since DC fast charging is an essential building block for the functional and comfortable use of electromobility and will therefore be a decisive aspect for the acceptance, this lack is a considerable limitation in achieving the electromobility goals of the German Government and NPE (one million electric vehicles by 2020). Therefore, the recommendation to the NPE AG 3 and NPE AG 4 is to initiate an economically reasonable solution. This can, for example, include the necessary steps for the development of economically usable and calibration-conforming meters or a different method for economical and legally compliant billing methods. **Suggestion 4.2.3.1**

The standardisation of metering technology for charging at frequencies other than the standard grid frequency would be a great help for regulatory measures in this field.

Billing and payment

Infrastructure services have to be accounted, billed and paid for in compliance with current laws. This applies both to parking space management and to the supply of electricity to various charging locations, if this is directly charged to the end consumer. Due to the continually increasing proportion of fluctuating power available in the grid, load management and storage management will pose new challenges to mass-market billing services. Suitable business models (“intelligent tariffs”) based on appropriate services can be used to influence consumer behaviour and thus achieve a better balance between supply and demand in the grid.

On the other hand, the consumption of electrical energy without separate billing systems, or without billing systems that differentiate prices according to volume (e.g. electricity flat rates), would lead to a situation in which the contributing new, controllable and/or switchable consumer devices in electricity supply grids cannot be fully exploited. In the interest of the successful deployment of electromobility, there is therefore a need to develop billing services which provide a transparent basis for well-informed, rational and sustainable decisions by the respective actors.

To promote the swift and economical introduction of electromobility throughout Germany, existing system expertise should be explored and furthered in order to develop the required accounting and billing systems. For example, in Germany, as opposed to other countries, it is already possible for several electricity retailers to be active “in one grid”, thus allowing consumers to change suppliers if they so wish. A similar problem can arise, for instance, if customers of a specific electricity retailer drive their electric cars to a workplace in a different grid area but still want to be billed by the same electricity supplier. There are already several possible approaches towards solving these issues which need to be expanded upon to ensure open competition in the domain billing systems for the energy supply of electric vehicles.

Market processes and communication methods which could facilitate or enable collaboration between various – and new – market actors have been defined recently, particularly in the liberalised energy market environment. The extent to which experience gained here can be transferred to billing services in the electromobility context is to be investigated. Conversely, existing standard processes should be reviewed to determine the extent to which they have to be optimised or adapted specially for mobile consumers. The various stakeholders and the German Federal Network Agency are jointly developing standard commercial processes for the energy sector.

Web-based payment scenarios

There are already a great number of standards and specifications covering web-based payment (relating to payment transactions, but not to meter readings/data communication), and adherence to these is recommended. Some examples are:

- Requirements of the PCI SSC (Payment Cards Industry Security Standards Council), such as e.g. PCI-DSS – (https://www.pcisecuritystandards.org/minisite/en/index.html)

- EMVCo specifications for POS (point of sales) terminals – (http://www.emvco.com)
- Regulations issued by major credit card companies, e.g. VISA, MasterCard, Amex, etc.

4.2.4 Grid integration

Since the use of electric vehicles and renewable energy sources would mean that more new energy producers and consumers would be additionally linked up to the grid, it should be examined as to whether grid stability and quality can still be ensured under these conditions. If this is not the case, then stricter requirements on producers and consumers must be defined, or appropriate compensation must be provided.

Load management

In terms of the smart grid concept, the electric vehicle is to be regarded as a consumer of electric energy, or (in the case of V2G feedback) a mobile storage device. One of the objectives of a smart grid is to influence energy consumption in such a way that it is easier to integrate renewable, more volatile energy sources into the overall system. As electrical energy can only be stored to a limited extent, the load profile is to be influenced in such a way that energy from sustainable or renewable sources can be used efficiently. The aim of load management is therefore to influence energy consumption as a function of time in such a way that consumption is more closely aligned with the supply situation. Three types of load management are being discussed:

- Demand response charging (one way communication based on broadcast price signals)
- Smart charging (charging negotiated between the car and the charging infrastructure operator through two-way communication)
- Charging controlled by the charging infrastructure operator

An incentive-based control system can be a powerful motivation for users not to charge their car batteries at peak load times, but to wait until conditions are more favourable. In this scenario, the incentive-based control system must consider, amongst others, the requirements of the energy market grids.

Especially in the initial introduction period, it is expected that customers will associate their electric vehicle with their environmental protection ambitions. Load management can help towards achieving the ultimate aim of CO_2-optimised mobility. In the extreme case, only energy from renewable sources and which is not needed for other purposes at the time would be used for charging vehicle batteries. From a technical perspective, load management options will be greater if high load power is available and/or the vehicles are regularly integrated into the grid, even when there is no acute need to charge them.

The approaches discussed, namely direct control or influence by incentives, must be brought in line with user behaviour, e.g. by specifying the time it should take to charge the battery. The longer the time frame specified by the user, the more flexible the choice of time at which the battery is charged, and the higher the probability that the user will be able to charge with fewer CO_2 emissions and at lower prices.

Grid services
If the units connected to the grid are to function properly, the voltages and frequencies guaranteed by the grid operator must be maintained. Draft standard ISO/IEC 15118 takes into account control of the effective power. Up to now, no standards have been developed in the controlling of reactive power and measures to maintain a stable frequency.

On the basis of experience gained with photovoltaic systems (e.g. the "50.2 Hz problem" and the necessary retrofitting of existing systems), and in view of the intended grid penetration by electric vehicles, suitable technical measures must be agreed upon and standardised at an early stage in order to ensure integration into the smart grid. Voltage, in particular, is a location-dependent quantity which depends on the grid connection point. Here it is important to define a systemic approach (central v. decentral). In order to achieve the competitive commercialisation of grid services for the benefit of car drivers (for example by offering especially favourable tariffs/rates), the contribution of the various system participants also has to be measured. In order to be able to ensure that charging loads are distributed evenly within the grid, solutions must be developed to avoid any load imbalances in the grid.

Storage management (including feedback)
It is conceivable that in a further step electric vehicle batteries will not only be used for consuming energy from renewable sources, but also for helping to bridge periods in which less energy from renewable sources is fed into the grid. Load management would provide control in one energy flow direction. If control in the opposite direction could also be implemented, this control would have an effect in the other direction and would influence grid control much more efficiently.

In terms of the smart grid, various strategies for minimising the number of conventional backup power stations are being discussed and tested. One of these strategies is load management. A large number of electric vehicles, which are also able to feed energy from their batteries back into the grid for a short time, would open up a further possibility. Feedback from electric vehicles could contribute to grid stability, particularly where there are short fluctuations in the input from solar or wind farms, but would not drain large amounts of energy from the vehicles. Thus, in cases of emergency or short-term fluctuations, electric vehicles would be able to support grid stabilisation until other power stations can be started up and synchronised with the grid.

The feedback process can have a negative effect on battery service life, which will have to be taken into consideration when discussing this topic. On the other hand, for the flexible use of volatile renewable energy such as wind power and, in particular, solar energy, a second-life approach to the utilisation of vehicle batteries might be considered, and is worth discussing in this context.

Basic mechanisms for load and storage management and the transmission of dynamic price information are defined in IEC 61850 and IEC 61968 through to IEC 61970.

Suggestion 4.2.4.1
Respective standards for feedback ability must be developed further since the introduction of electromobility will provide a considerable advantage.

4.2.5 Data security and data privacy

Electromobility will result in a large amount of information that will be collected and stored at various points and exchanged via various communications interfaces between the involved parties. Ensuring adequate security of these data and of the data processing systems is therefore of great importance. Where this data is of a personal nature, ensuring comprehensive data privacy is particularly important for the wide acceptance of electromobility. Data security and data privacy are thus interdisciplinary issues that must be dealt with for all individual systems and communication interfaces.

General suggestion

Therefore, this topic is of great importance and the provisions of the national Energy Industry Act (EnWG) must be taken into account. Important areas to be considered are:

- Data sovereignty
- Data avoidance
- Pseudonymisation
- Data minimisation
- Granularity of transmitted data
- Limitation of authorised data receivers or users
- Manipulation protection
- Data with personal references
- BSI regulations

Suggestion 4.2.5.1

Due to the central importance the EnBW attaches to the BSI in terms of enforcement of data security and data protection when trading with electrical energy, the inclusion of the BSI for a connection of standardisation activities and legal provisions on data security was ensured in DKE/STD 1911.11.5. An involvement of NA 043-01-25 AA should also be pursued in this matter.

Owing to the many types of communication interfaces between the various systems, a number of data security threats and data protection violations are possible and must be taken into consideration. Examples of such threats are:

- Attacks on central systems for energy trading transactions and payment settlement, with the objective of compromising and manipulating these systems.
- Attacks on central systems for controlling energy supply grids and/or attacks on the smart grid infrastructure with the aim of manipulating it, and particularly disrupting the operation of energy supply networks.
- Attacks on central systems for services (fleet management, vehicle maintenance etc.).
- Attacks on distributed systems in the charging infrastructure, for instance with intent to manipulate or gain unauthorised access to billing data.
- Attacks on terminal devices in vehicles, for instance to manipulate billing data or possibly to gain unauthorised access to vehicle movement data.
- Attacks on the vehicles' internal communication networks (control units, driver assistance systems, communications systems, value-added services) via the communication connection to the charging stations.
- Violation of data privacy laws other than those already mentioned.

Luckily, there are already many internationally accepted and widely applied standards concerning information security which can also be used to ensure data security and privacy in the electromobility environment. In this context, particular reference is made to the following standards:

- Standard collection ISO/IEC 27000
  The fundamental standard ISO/IEC 27001 describes an information security management system which is generally suitable for the appropriate handling of information security issues and for the implementation of suitable measures. Application of this standard is therefore recommended for all relevant sectors and operators of information technology systems related to electromobility. Furthermore, the recommendations made in ISO/IEC 27001 for the implementation of the ISO/IEC 27002 controls can be applied directly to trading platforms and commercial systems and their associated communication networks and interfaces. We do not consider that any further standardisation is necessary in these areas.
- Protection of communications with the control systems of the energy supply grid
  Some mechanisms for protecting communications with grid control systems are already provided in the communication protocols used (especially in IEC 61850) or are additionally defined in supplementary standards (e.g. IEC 62351). Some of the many activities currently being undertaken to further develop existing energy supply networks into “smart grids” are the efforts being made to apply and amend these standards. We do not consider that any further standardisation is necessary from the security standpoint.
- ISO/IEC TR 27919 (formerly DIN SPEC 27009) “Information security management guidelines based on ISO/IEC 27002 for process control systems specific to the energy utility industry”.
  ISO/IEC TR 27019 resulted from the German DIN SPEC 27009 and describes implementation suggestions for safety measures (“controls”) from ISO/IEC 27009 for energy generation and its distribution network. Therefore, it can also be applied to the infrastructure upstream of the charging point in the energy network.

To supplement the existing standards listed above, we consider that additional standardisation activities are needed in the following areas specifically for the electromobility sector:

- Protection of communications interfaces specifically used in electromobility
  The communications interfaces defined as part of electromobility standardisation activities should have inherent security features and mechanisms. These include methods for the reliable authentication of communication partners, for ensuring the confidentiality and integrity of exchanged data, and for ensuring the traceability of transactions. The relevant interfaces include, for example, communication interfaces between the vehicle and charging station (IEC 61851-23/24), and car-to-supply grid interfaces (ISO/IEC 15118). It should be reviewed whether separate standards are needed for such protection or whether the protection mechanisms can be dealt with directly in current standards. Since cryptographic methods are normally used for protecting communication interfaces which require the provision of key material for all communications partners, it must also be examined whether additional standards are required for providing and distributing key material to all participants.
- Protection of devices in vehicles and charging stations
  The protection profiles according to common criteria (ISO/IEC 15408 series) have proven useful in defining the security features of devices. In particular, these profiles permit a neutral verification and certification of systems made by different manufacturers. Protection profiles according to ISO/IEC 15408 are already used for digital tachographs, for example, or will be used in the future for meter interface systems in the smart metering/smart grid environment. With regard to the electromobility sector, we consider it necessary to define protection profiles for the communication systems and components of vehicles and charging stations.

4.2.6 Current standardisation activities relating to interfaces and communications

At present, there are several international standards and projects dealing with interfaces and communications at an international level. Figure 12 shows the most important standards on conductive and inductive charging.

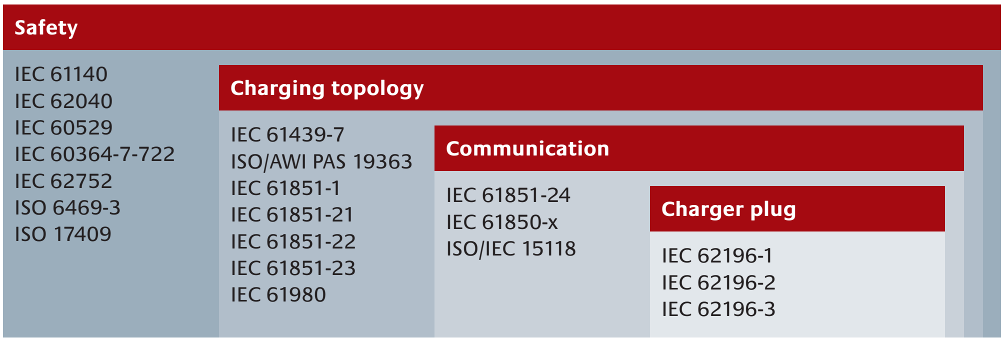


Figure 12: Selection of standards and projects relating to the charging interface

4.2.7 Ergonomics of interaction between the consumer and the charging infrastructure

Ergonomics in the context of electromobility involves optimising the user-friendliness and serviceability of the charging infrastructure. Scientific findings in the fields of information psychology, biology, and industrial design and engineering can help make the user's inevitable interaction with the charging infrastructure as positive an experience as possible.

Ergonomics standards

Standardisation of the ergonomics of the charging infrastructure pursues three main aims:

- Minimising health risks
- Avoiding operating errors
- Increased ease of charging by minimising the cognitive stress on the user.

The intention is to define minimum requirements for each of these three aspects, thus creating decisive factors which reinforce the end consumer's positive attitude towards electromobility, which in turn supports its success.

When users need to recharge their vehicle, they will probably have limited options in terms of the attractiveness of charging stations. In view of the need for the greatest possible user acceptance and ease of operation, it would take too long to allow acceptable ergonomic solutions to evolve only on the basis of the competitive market. Standardisation could help solve this problem. However, the success of the best products developed on the basis of ergonomics standards should be left to the market.

Two important use-cases regarding interaction with the infrastructure

Any approaches which are standardised should take into consideration the two most important use cases regarding interaction between the user and the infrastructure: the process of locating the charging station, and the charging process itself.

- **Locating the charging station**
  With current state-of-the-art electrical energy storage technology, electric vehicles will have to be charged much more often than vehicles with internal combustion engines need to be refuelled. For this reason it is important that the driver plans the "when and where" of charging electric vehicles more carefully. Guidance systems leading to the charging stations are required both in indoor environments (e.g. underground car parks) and outdoors (e.g. in rural areas). It can be expected that satellite-supported navigation systems will be used right up to the last metre in outdoor environments. Most infrastructure operators already provide geo-data on their charging infrastructure, but as yet there are no multi-operator platforms. Here, standardised data formats would be useful, since these could contain not only location data but also further information on the services provided at the various charging stations. Other orientation aids might be printed versions of special maps or plans (for indoor areas). In both environments there will be signs, signposts and other kinds of physical orientation aids indicating the locations of the charging stations and the services provided (e.g. AC, 3-phase AC, DC, possible forms of payment etc.). Regardless

of the type of guidance medium, the following attributes are suitable for standardisation, for instance:
- colours
- shapes
- symbols
- descriptors
- minimum dimensions
- spatial distance

On the topic of locating a charging station, a review of the required standardisation is seen as necessary, for example for a definition of a uniform, open status signal with respect to “charging station free/occupied/reserved”, etc. Transferring this issue to NPE is also possible.

- **Charging process**
The charging process is the point at which the user comes into direct contact with the charging station technology. This human/machine interface must be optimised with regard to the following basic ergonomic parameters:
  - language suitable for the user’s familiarity with the system
  - uniform terminology
  - meaningful grouping of user interface elements
  - visibility of the system status indicator
  - visual and/or auditory feedback
  - possibility of stopping/interrupting the charging process
  - conformity to expectations
  - mechanical elements that take the size and strength of users into consideration
  - design elements that take the needs of the elderly into account

  Standardisation is helpful in designing displays and other operating elements used to implement the aforementioned points, as well as other charging station elements that support human-machine communication in any way. In particular, the following design parameters apply to the interaction elements as well:
  - colours
  - shapes
  - symbols
  - descriptors
  - minimum sizes (e.g. font sizes)
  - spatial distances

  as well as
  - minimum luminosity and contrast of display
  - maximum values for forces required to operate switches and controls.

A number of existing ergonomics standards can be used in the development of ergonomic minimum standards for the charging infrastructure interaction ergonomics. DIN ISO 7000, for example, contains a large number of symbols and pictograms. DIN’s Ergonomics Standards Committee, particularly NA 023-00-04-08 GAK “Ergonomische Aspekte zu E-Energy und Smart Grids” (Ergonomic aspects of renewable energy and smart grids), are responsible for the standardisation of the ergonomic aspects of the charging infrastructure.

Suggestion 4.2.7.1

The use of graphic symbols is recommended for the operator interface in order to ensure intuitive and easy use by different users. It must be reviewed to which extent graphic symbols are used for the human/machine interaction and safety labelling and whether standardisation is required. At the moment, standardisation activities are already underway in ISO/TC22/SC13 WG5 with regard to determining a basic symbol to indicate the location of charging stations in navigation systems and on the vehicle’s display panel. At the DKE, DKE/K 116 is currently working on the topic “Graphic symbols for human/machine interaction: safety labelling”. Harmonisation of the various activities is desirable.

In this context, the requirement for standardisation for a uniform, barrier-free access must be examined. Further research projects in Germany must be included that are based on previous knowledge, for example for user identification with QR and text messages at charging stations or the automatic connection of the electric vehicle. Other access and identification mechanisms for the charging infrastructure such as RFID should be reviewed. Standardisation of user identification with a smart card is currently addressed in the development of IEC 62831.

4.3 Electric vehicles

The German Standardisation Roadmap for Electromobility deals with road vehicles which are fully or partially propelled by an electric motor. Top priority is given to category M1 vehicles (passenger cars), but also the categories M2, M3, N1, N2 and N3 as well as the so-called “light electric vehicles” (LEV) of category L are taken into consideration (see B.1.3).

The vehicle categories M and N are considered to have particularly high potential for the successful introduction of electromobility due to the increase in population in cities and the decrease in population in rural areas. It seems reasonable to divide utility vehicles and buses categorised as M into the three categories regular, distribution and long-distance traffic. Similar routes are expected in regular traffic, while unstructured routes within a city and region are expected for distribution traffic. In contrast, unstructured routes at a national and international level are expected for long-distance traffic. While normal charging at the station (mode 3 with $P \leq 50$ kW) should occur in all categories, fast charging is only realistic in regular and long-distance traffic on circulars and routes (mode 4/X with $P \geq 500$ kW). The categories named differ in terms of daily range, vehicle category, energy demand, charging duration and service life (see B.1.4). The requirement for research projects for utility vehicles and buses categorised as M and N was identified especially with respect to their charging processes. The tasks to be completed for a successful introduction of electric utility vehicles into the vehicle categories M2, M3 and N relate to automated conductive DC (based on loading operating mode) and inductive charging systems for high-performance battery systems and information exchange via radio systems. However, initiating standards, for example by the committees DKE/K 351 “Electric equipment for trains” and DKE/K 353 “Electric road vehicles”, for utility vehicles and buses in the categories M2, M3 and N seems premature.

The currently ongoing developments of off-road vehicles must be continued to be supported. However, a discussion of this topic in the present standardisation roadmap seems premature.

Two-wheel, three-wheel and light four-wheel vehicles (class L1e, L2e, L3e, L4e, L5e, L6e, L7e) are considered as being in the category LEV. In addition to passenger cars, light utility vehicles and buses, this category is of decisive importance, since the supply of light electric vehicles especially in metropolitan areas is a fundamental requirement for the overall success of electromobility and its wide uptake. The requirements for concepts and, therefore, for standards sometimes differ considerably from those for passenger cars. Timely standardisation – especially for LEV – is of great importance for the overall market success of this vehicle category. It is of further importance to take into account the category of electric bicycles (so-called pedelecs/$v_{max} \leq 25$ km/h), which can be operated without a driving licence.

4.3.1 System approaches for the drive

There are several different drive concepts for road vehicles. Figure 13 gives an overview of these, with the degree of electrification rising from left to right. Vehicles powered exclusively by internal combustion engines are not included in the present German Standardisation Roadmap for Electromobility.

However, the operation of vehicles with combustion engines clearly differs from the operation of pure electric vehicles. For this reason, there is a research demand for pure electric vehicles on the topic "Determination of load spectrums". **Suggestion 4.3.1.1**

Considering the current market situation and product announcements by vehicle manufacturers, it is clear that hybrid vehicles will play a vital role in electromobility in the coming decade. These vehicles are characterised by the fact that they have both an internal combustion engine and an electric means of propulsion.

Combustion	Hybrid	Electric
Petrol engine	Plug-in-Hybrid Electric Vehicle (PHEV)	Fuel cell
Diesel engine	Range Extended Electric Vehicle (REEV)	Battery Electric Vehicle (BEV)
H_2 engine		

Figure 13: Degree of electrification of road vehicles

As the examples in Figure 14 show, the electrical energy for vehicles propelled exclusively by electric motors can be supplied in various ways.

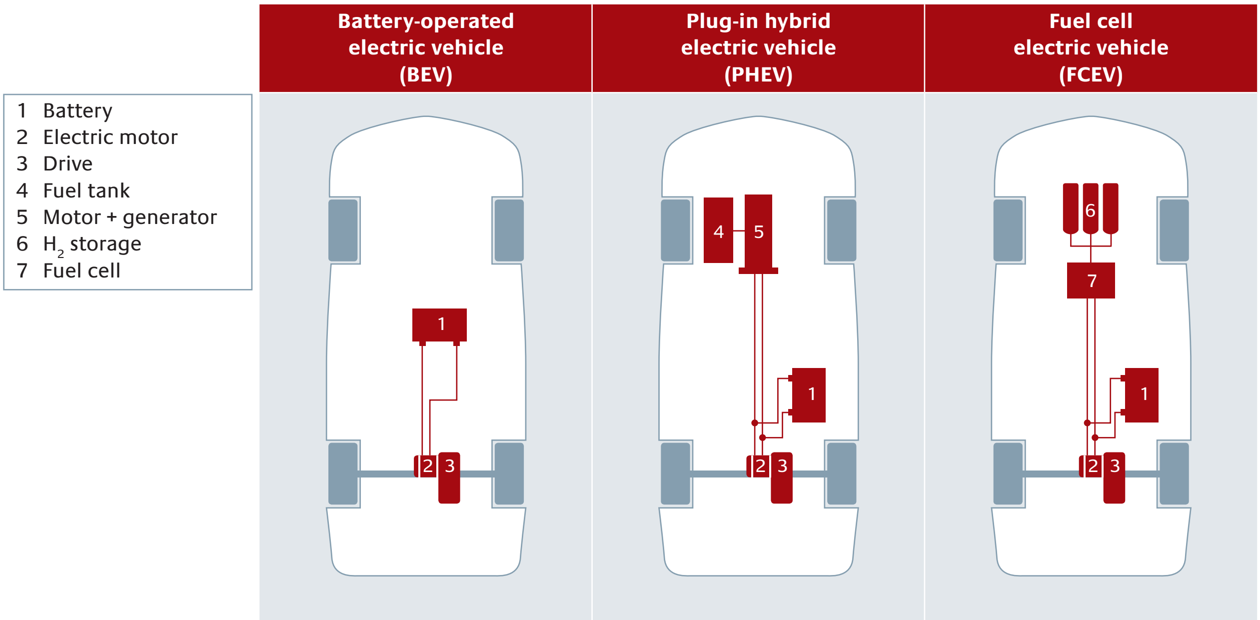


Figure 14: Examples of the drive configurations of electric vehicles

In view of these reference vehicle features and the current state of the art, it can be expected that over the coming years battery voltages will be in the 200 V to 600 V range at battery currents of up to approximately 300 A. Higher voltages allows lower currents and smaller cable cross-sections are currently being examined by the automotive industry, but the prerequisites for standardisation in this field are not yet in place. Cables and wires for use in road vehicles are standardised in ISO 6722. The standard ISO 19642 is currently under development at TC 22/SC 03/WG 04.

Battery voltages of under 60 V are often used in small vehicles (e.g. electric bicycles). Nevertheless, the topics of electrical safety, EMC and possibly further categories of device safety still have to be taken into account for these vehicles and the charging devices they use.

4.3.2 System approaches for the charging process

Currently, several system approaches and charging processes are being discussed. These approaches meet the demands of the various stakeholder groups, although these demands are sometimes in conflict with one another:

- safety
- wide availability from the very start
- charging duration
- ease of use
- cost, weight and space taken up in the vehicle
- possibility of load management

- possibility of feeding energy back to the grid
- international compatibility

The AC and DC charging processes for electric vehicles are distinguished according to the kind of current, i.e. how the current flows between the external charging device and the vehicle. In AC charging devices, the charger (rectifier) is installed in the vehicle. In DC charging devices, the charger (rectifier) is installed outside of the vehicle, namely in the DC charging station.

Note: Charging using an external charger, even with low charging performance, is a variant of DC charging.

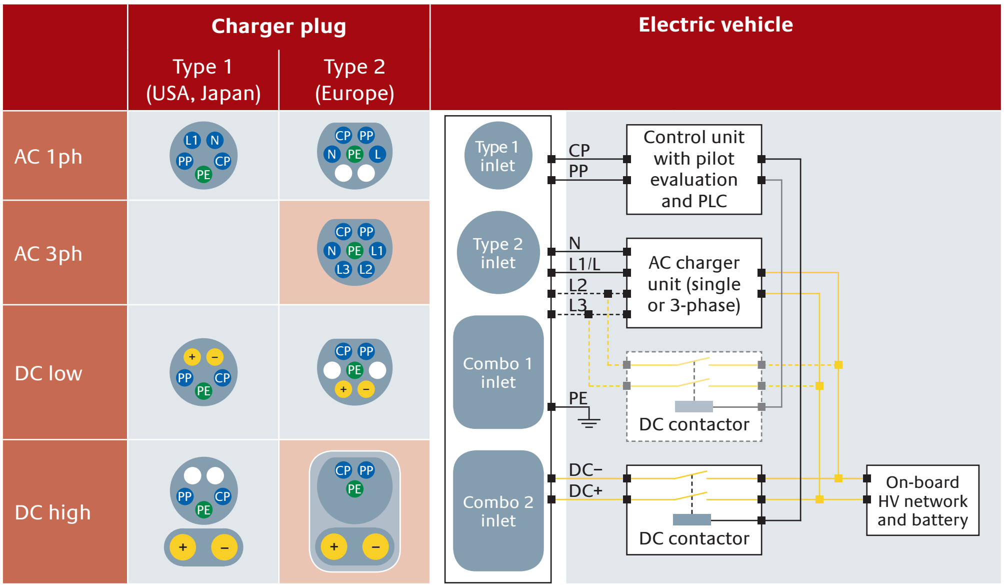
For charging powers up to 3.7 kW the use of a dedicated charging device in the vehicle and a single-phase connection is state-of-the-art technology in terms of a basic solution (ideally in mode 3). For charging powers higher than 3.7 kW the following two alternative AC charging options are available:

a) AC 3-phase charging with a dedicated high-power charger installed in the vehicle
b) AC 3-phase charging using existing components (motor inverter)

The DC charging process known as “fast charging”, depending on the charging speed, allows a comfortable extension of the range for vehicles powered by battery only (at present, up to 10 km/min are considered to be realistic).

The “Combined Charging System (CCS)” for the AC and DC charging of electric vehicles
German and American automobile manufacturers, in cooperation with charging station and accessories manufacturers, are currently developing and standardising a universal charging system suitable for both AC and DC charging called the CCS (for definition, see B.1.9).

The central approach of this system is the use of a single charging power inlet on the vehicle (“combo inlet”) and the joint use of PLC (power line communication) technology for the ancillary services during AC charging procedures (optional) and for communications during the entire DC charging process (see Figure 15).



Standardised charging plug and preferred solution according to EU directive

Figure 15: Combined charging system for AC and DC charging using charging devices of type 1/type 2 and combo 1/combo 2, respectively

Numerous functions and safety measures will ensure ease of use so that users will not even have to consider whether the charging station provides AC or DC charging services and which inlet to use. This means that fully automated charging procedures can be realised with the aid of the communications content in ISO/IEC 15118. In addition, there are measures for the safe alternating use of contacts for AC and DC charging as well as protective measures against arcing caused by the inadvertent disconnection of the vehicle connector during the charging process. The backwards compatible integration of load management and authentication as well as DC charging at a joint charging connection at the vehicle represent an advantage compared to the CHAdeMO charging system available in the European market which the customers can experience. In CHAdemMO, DC charging is achieved with an additional charging connection without a protective earth conductor PE.

Inductive charging: ISO 19363 specifies the vehicle-specific requirements for inductive charging. The work is reflected at NAAutombil in the working group NA 052-01-21-05 GAK.

Charging interface for light electric vehicles

Compared to normal vehicles, adapted framework conditions apply to the group of light electric vehicles (LEVs). Early standardisation is of essential importance for their wide uptake.

The requirements regarding the charging interface for LEVs are specified in the standards series IEC/TS 61851-1 currently under development. This project considers AC and DC charging as well as battery changing systems and communication of LEVs. Standards and specifications developed for LEVs are based on the main standard IEC 61851-1. Thus, a vehicle can use the already existing infrastructure if IEC 61851-1 and the standards referenced therein are fully implemented. The requirements for range and battery capacity are lower for LEVs than for passenger cars. Thus, the charging power for LEVs does not necessarily need to be that high.

Requirements regarding plugs for AC and DC charging will be specified in future in IEC/TS 62196-4. However, the country-specific plug, e.g. Schuko-plug, is of essential importance for the AC charging of pedelecs and small LEVs as the battery is often removable and charged at a plug point at home. To also be able to charge these vehicles in the public space, this type of plug point must also be available in the infrastructure. This would enable a simultaneous charging of LEVs and passenger cars. The required safety is achieved with suitable measures, e.g. a charger of protection class II and low voltage (< 60 V). DC fast charging columns will have to have their own infrastructure since the power range of current charging columns covers a different voltage. These requirements are specified in IEC TS 61851-3.

Suggestion 4.3.2.1

The solutions to be standardised in the standards series IEC 61851-3 should complement the existing charging modes of IEC 61851-1 (charging mode 1 to 4) (e.g. regarding the voltage range) and not define competing charging modes). Interoperable solutions should be standardised since these are seen as the (future) expectations of the users.

Requirements for light electric vehicles and electric bicycles

CEN TC 333 is responsible for standardising activities for bicycles. EN 15194 contains safety-related requirements and test methods for “electrically power assisted cycles” (EPAC). EC 14764 “City and trekking bicycles” is referenced with respect to the testing of operational stability of the components. Other standards can be referenced with respect to requirements and the testing of electric and electronic components. A BATSO standard was developed for the safety of lithium-ion batteries.

Standardisation activities for the requirements for light electric vehicles happen internationally at ISO/TC 22/SC 27 and nationally at NA 052-01-22 AA. There, the project ISO 18243 “Electrically propelled mopeds and motorcycles – Specifications and safety requirements for lithium-ion battery systems” is in progress.

4.3.3 Safety

Electrical safety

Essential safety requirements for the electric vehicle, its rechargeable energy storage system, the operational safety of electrical systems, and the safety of persons are covered in ISO 6469. Cables for use in road vehicles in voltage classes 60 V and 600 V are standardised in ISO 6722 and ISO 14572. ISO 17409 specifies the safety requirements for the vehicle when connecting to a charging station.

- **Battery and DC voltages exceeding 400/600 V**
  The automobile and automotive supply industries have begun developing applications using system voltages or battery voltages exceeding 600 V. The corresponding safety standards will have to be elaborated or modified as soon as possible.
- **Accidents and crashes**
  As far as accidents are concerned, rescue guidelines also have to be taken into consideration so that rescue workers are provided with all relevant information. Due to the

increased complexity of the requirements to be observed during rescue operations, the structure of rescue guidelines for such vehicles needs to be standardised.

Suggestion 4.3.3.1

At ISO TC 22, the standard ISO 6469-4 “Electrically propelled road vehicles – Safety specifications – Post crash safety requirements” is under development, which specifies requirements for the vehicle after an accident. Finalising and publishing this standard must be aimed for as quickly as possible under German management. Germany is also involved in the development of standard ISO 17840 “Road vehicles – Information for first and second responders – Rescue sheet for passenger cars and light commercial vehicles” on rescue sheets, which should be finalised quickly. Rescue sheets form an information basis for rescue personnel and provide, amongst others, positioning and information on relevant components (HV line, control devices, batteries, etc.) for vehicles with alternative propulsion systems. Furthermore, it must be examined how battery systems can be put into a safe state after a serious accident. An accident can damage the battery in such a way that a safe recovery of the vehicle is not immediately possible. In order to avoid a hazard for rescue and vehicle recovery personnel, it must be possible to determine whether a battery can be transported safely. If this is not the case, it must be clarified whether and under which conditions the battery can be put into a safe state again (e.g. controlled discharging). This problem must be investigated in research institutions. Subsequently, the requirements for standardisation must be defined and the research results must be implemented quickly in corresponding standards, e.g. for defined interfaces for the safe discharging of damaged batteries.

- **Functional safety**
  The ISO 26262 series covers functional safety in the automotive sector (HW and SW systems).
- **Fire hazard of lithium-ion batteries**

Suggestion 4.3.3.2

In order to reduce fire hazards, the storage of lithium-ion batteries requires compliance with specific regulations. Thus, standards must be developed over a medium-term duration.

4.3.4 Components

All standardisation activities in the components domain of the automotive industry focus on requirements on quality and performance, classification, and, where appropriate, interfaces to other components or systems. In the electromobility field, there are opportunities for an early development of standards which can then be referred to in relevant regulations. This is especially true of electric vehicle components and will enable synergy effects within Germany’s globally leading automotive industry. Furthermore, some of the existing standards and specifications will have to be extended and modified. This applies for example to standards and specifications covering the technical characteristics of cables and fuses, and to standards on testing the suitability of components for automotive applications.

Suggestion 4.3.4.1

ISO 16750 “Road vehicles – Environmental conditions and testing for electrical an electronic equipment” must be reviewed and it must be determined whether this standard should be extended to environmental conditions for electric and electronic systems in road vehicles.

The following, currently ongoing project should also be considered and should be concluded under German management:

- ISO/AWI 19453 “Road vehicles – Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles”.
- ISO/AWI PAS 19295 “Electrically propelled road vehicles – Specification of voltage sub-classes for voltage class B”

In addition, the following standards must be reviewed for possible amendments for the overall vehicle including the drive train:

- ISO 23828 “Fuel cell road vehicles – Energy consumption measurement – Vehicles with compressed hydrogen”
- Standards series ISO 23274 “Hybrid-electric road vehicles – Exhaust emissions and fuels consumption measurements”
- ISO TR 11954 “Fuel cell road vehicles – Maximum speed measurement”
- ISO TR 11955 “Hybrid-electric road vehicles – Guidelines for charge balance measurement”
- ISO 8715 “Electric road vehicles – Road operating characteristics”

Furthermore, specifications on current consumption values while idle are currently being prepared for electric vehicles.

4.3.5 Batteries

Only lithium-ion batteries have been considered in the German Standardisation Roadmap for Electromobility. Other technologies are not explicitly discussed because, in the opinion of experts, their use will play only a subordinate role in the coming decade. As far as energy storage density and handling are concerned, lithium-ion batteries are currently the best technical solution.

Its volume and mass make the traction battery a dominant system component in vehicles. Standardising the external geometry of the battery would lead to a considerable restriction of freedom in vehicle design as well as in the optimisation of mass, functionality and user-friendliness. Apart from this, the wide variety of vehicle types (city car, small car, family car, sports car, SUV, bus, lorry, etc.) counteracts the effects of standardising battery geometry, as this would only necessitate increased efforts in vehicle design which cannot be compensated by the advantages in battery design. However, standardising the dimensions and contact locations of battery cells for use in automotive applications would support effective system development. Standardisation of the dimensions of cells and the position of contact locations within the battery system was implemented successfully at an international and national level. ISO/PAS 16898 “Electrically propelled road vehicles – Dimensions and designation of secondary lithium-ion cells” was published in 2012; DIN SPEC 91252 “Electric road vehicles – Battery systems – Dimensions for lithium-ion cells” was published in 2011.

Suggestion 4.3.5.1

Furthermore, the development of standard ISO 18300 "Electrically propelled road vehicles – Specifications for lithium-ion battery systems combined with lead acid battery or capacitator" must be concluded quickly under German management.

The safety of battery systems is an area where aiming for uniform standards must be of highest priority. Uniform test methods for battery systems and battery cells for the evaluation of safety and performance characteristics are specified at ISO and IEC. The ISO 12405 series "Electrically propelled road vehicles – Test specification for lithium-Ion traction battery systems" must be considered in this context and specifies applied system tests. Testing of the cells is described in the standards series IEC 62660 "Secondary batteries for the propulsion of electric road vehicles". Ongoing work on IEC 62660-3 "Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 3: Safety requirements for cells and modules" must be concluded quickly. The necessity of CoP (conformity of production) standards should be reconsidered in order to be able to monitor the "inner values" of the battery cells after the production process. The current test methods must be further developed and continuously adapted to international requirements.

There is currently no immediate demand for a standard which can be used to determine the remaining operating life of the battery by saving the necessary parameters. The possibility to determine the remaining operating life is the subject of current research projects. Depending on these research results, the requirement for standardisation should be evaluated afterwards.

Replacement of batteries or rechargeable batteries is an established solution for pedelecs that are already on the market. The standardisation of the interface with rechargeable replacement batteries will lead to scale economies and the potential to save costs.

4.3.6 Fuel cells

The industry is developing fuel cells and the related hydrogen supply infrastructure in parallel. Many of the measures concerning corresponding regulations at the European and international level have already reached an advanced status and should be implemented as quickly as possible. In Germany, measures are being coordinated by "NOW GmbH" (Nationale Organisation Wasserstoff-Brennstoffzellen – National Organisation of Hydrogen and Fuel Cell Technology) in close cooperation with the relevant federal ministries.

General suggestion

The use of fuel cells will occur with a certain time delay compared to the use of battery-driven vehicles. In order to avoid forcing technological developments in a certain direction at a premature stage, standardisation work in this field should be started as required; it is recommended to observe and follow the topic by the group DKE/K 384 "Fuel cells" as well as NPE AG 4.

4.3.7 Capacitors

Capacitors in the form of double-layer capacitors (super-capacitors and ultra-capacitors) can be used as energy storage devices for electric vehicles. At present, these are of relevance particularly for hybrid vehicle applications. The high energy storage density of capacitors plays an important role here. IEC 62576 "Electric double-layer capacitors for use in hybrid electric vehicles – Test methods for electrical characteristics" describes testing procedures for electric parameters.

Suggestion 4.3.7.1

There is a research demand for capacitors for electric drives. The coordination of NWIP IEC 69/243/NP developing the standard "Electric double-layer capacitors for automotive applications – Test methods for electrical characteristics, life-time and durability, environmental performance and safety" should be continuously followed.

4.3.8 Special use-case scenarios – breakdown service

Roadside assistance for vehicles that have stalled due to a depleted battery can be considered as a special use case. Special vehicles with an autonomous electricity supply (from a generator) and a powerful on-board AC or DC charging station could be deployed for this purpose: the stalled vehicle could be connected to this special vehicle using a standard charging cable to transfer a fairly large amount of charging energy within a short time.

A feasible alternative for the future when cars with V2G capability will be available might be to transfer energy from one vehicle to another. This special case in which a vehicle acts as a temporary charging station will have to be included as a separate topic in the ISO/IEC 15118 communications standard. Furthermore, a special vehicle-to-vehicle cable would be needed for this procedure.

4.3.9 Current electric vehicles standardisation activities

When examining standardisation activities for electric vehicles, the respective scope of application with respect to vehicle categories must be considered. Figure 16 shows the status of the most important standardisation projects for electric vehicles.

Table 1: Overview of current standardisation activities relating to electric vehicles, August 2014

Designation	Subject/title	Status
ISO 6469-4	Electrically propelled road vehicles – Safety specifications – Part 4: Post crash electrical safety	DIS
ISO 10924-5	Road vehicles – Circuit breakers – Part 5: Circuit breakers with tabs with rated voltage of 450 V	DIS
ISO 11451-2	Road vehicles – Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 2: Off-vehicle radiation sources	FDIS
ISO 11451-3	Road vehicles – Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 3: On-board transmitter simulation	FDIS
ISO 15118-3	Road vehicles – Vehicle to grid communication interface – Part 3: Physical and data link layer requirements	FDIS

Designation	Subject/title	Status
ISO 15118-4	Road vehicles – Vehicle to grid communication interface – Part 4: Network and application protocol conformance test	CD
ISO 15118-5	Road vehicles – Vehicle to grid communication interface – Part 5: Physical layer and data link layer conformance test	CD
ISO 15118-6	Road vehicles – Vehicle to grid communication interface – Part 6: General information and use-case definition for wireless communication	CD
ISO 15118-7	Road vehicles – Vehicle to grid communication interface – Part 7: Network and application protocol requirements for wireless communication	AWI
ISO 15118-8	Road vehicles – Vehicle to grid communication interface – Part 8: Physical layer and data link layer requirements for wireless communication	AWI
ISO 17409	Electrically propelled road vehicles – Connection to an external electric power supply – Safety requirements	DIS
ISO 17840	Road vehicles – Information for first and second responders – Rescue sheet for passenger cars and light commercial vehicles	DIS
ISO 18243	Electrically propelled mopeds and motorcycles – Specifications and safety requirements for lithium-ion traction battery systems	CD
ISO 18300	Electrically propelled road vehicles – Specifications for lithium-ion battery systems combined with lead acid battery or capacitor	DIS
ISO PAS 19295	Electrically propelled road vehicles – Specification of voltage sub-classes for voltage class B	AWI
ISO PAS 19363	Electrically propelled road vehicles – Magnetic field wireless power transfer – Safety and interoperability requirements	AWI
ISO 19453 Parts 1 – 4	Road vehicles – Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles	AWI
ISO 19642 Parts 1 – 10	Road vehicles – Automotive cables	NP

Note: Other relevant standards relating to electromobility are listed in Table 2.

	Standard		AWI	CD	DIS	FDIS	IS
Vehicle	**ISO 6469-4** Electrically propelled road vehicles Safety specification – Post crash safety						2016
Vehicle	**ISO 11451** Electrically propelled road vehicles – Connection to an external electric power supply – Safety requirements						2015
Vehicle	**ISO/IEC 15118-1** V2G communication interface General information and use-case definition						2013
Vehicle	**ISO/IEC 15118-2** V2G communication interface Network and application protocol requirements						2014
Vehicle	**ISO/IEC 15118-3** V2G communication interface Physical and data link layer requirements						2015
Vehicle	**ISO/IEC 15118-4** V2G communication interface Network and application conformance test						2015
Vehicle	**ISO/IEC 15118-5** V2G communication interface Physical layer and data link layer conformance test	new					2017
Vehicle	**ISO/IEC 15118-6** V2G communication interface General information and use-case definition for wireless communication	new					2017
Vehicle	**ISO/IEC 15118-7** V2G communication interface Network and application protocol requirements for wireless communication	new					2017
Vehicle	**ISO/IEC 15118-8** V2G communication interface Physical layer and data link layer requirements for wireless communication	new					2017
Vehicle	**ISO 17409** Connection of the vehicle to the grid Changing interface for electric vehicles	new					2015
Vehicle	**ISO PAS 19295** Electrically propelled road vehicles Specification of voltage sub-classes for voltage class B						2018
Components	**ISO 10924-5** Road vehicles – Circuit breakers – Circuit breakers with tabs with rated voltage of 450 V						2015
Components	**ISO 12405-3** Test specification for lithium-ion traction battery packs and systems Safety performance requirements						2014
Components	**ISO 19642** Road vehicles Automative cables Part 1 – 10	new					2018
	Standard		AWI	CD	DIS	FDIS	IS

AWI Approved Work Item
CD Committee Draft
DIS Draft International Standard
FDIS Final Draft International Standard
IS International Standard

Phase completed

Phase not completed

Figure 16: Status of the major standardisation projects relating to electric vehicles, August 2014

4.4 Types of energy supply for electric vehicles

General suggestion

It must be possible to charge electric vehicles “anywhere and anytime”: the suggestion for a “Guideline of the European Parliament and Council of Europe on the construction of the infrastructure for alternative fuels” comprising the construction infrastructure of alternative fuels and the determination of uniform technical specifications in the European Union was confirmed by the European Parliament in April 2014. The interoperability of vehicles of different manufacturers and infrastructure of different operators must be ensured. Standardisation and specification of charging technology and payment/billing systems must ensure that a safe charging interface is created for the user, which is easy to use.

Suggestion 4.4.1

It is recommended to develop suitable standards for the payment/billing of charging with non-network frequency, which can be referenced in weights and measures authorisation provisions. This applies particularly for DC and inductive charging. The use of smart meters may also be considered for payment/billing. However, the requirements for example for data security must be taken into account. The provision development group of the PTB (Physical and Technical Institute of the Federal Republic of Germany) should be included.

Uniform roaming rules are therefore seen as necessary and approaches for standardisation must be reviewed soon. The user interests must have priority over the interests of individual companies. This statement also applies to the countries China, Japan and Korea intending to use separate vehicle inlets for AC and DC charging. ACEA demands the use of inlets of type 2 and combo 2. Thus, the use of the CCS charging system is recommended, which fulfils these requirements. A reduction of the globally used plug systems should be sought.

Charging stations can be installed in private, semi-private, public and semi-public areas. Depending on the location and the range of functions to be provided, several different functional units will be required.

Suggestion 4.4.2

The charging stations including charging modes are worked on in IEC/TC 69 for standards series IEC 61851 “Electric vehicle conductive charging system”. It must be ensured that IEC 61851 is prepared openly towards technologies. IEC 61851-1 must be reviewed with respect to the full support of the described approach for DC charging (CCS).

The contents of IEC 61851 part 21 and ISO 17409 should be preferably prepared in cooperation with mode 5.

IEC 61851-1 currently defines four conductive charging modes. Modes 1 to 3 relate to charging with a charger unit installed in the vehicle (on-board charger); mode 4 describes the use of an “off-board charger”.

- Mode 1:
  - AC charging at normal mains outlets with up to 16 A
  - single-phase 250 V (AC), or three-phase 480 V (AC) *)
  - no protection devices prescribed in the charging cable
  - RCD in domestic installations an essential prerequisite
  - no energy feedback, no communications
  - prohibited e.g. in the USA
- Mode 2:
  - AC charging at normal mains outlets with up to 32 A
  - single-phase 250 V (AC), or three-phase 480 V (AC) *)
  - charger cable with integrated safety devices in an in-cable control box comprising IC-CPD, control pilot and proximity sensor
  - without energy feedback, communications between the in-cable control box and the electric vehicle is possible via the control pilot
- Mode 3:
  - AC charging at special charging stations with up to 63 A
  - single-phase 250 V (AC), or three-phase 480 V (AC)*)
  - charging cable with plug in accordance with IEC 62196-2
  - no IC-CPD required in the cable, as the safety equipment is a permanent part of the charging station
  - plug interlock permits unsupervised operation, even in a public space
  - as opposed to modes 1 and 2, energy feedback is possible, since communications are bidirectional throughout, control is possible and plugs can be locked
- Mode 4: DC charging with off-board charging equipment
  - DC charging with special charging stations, mostly quick-charging stations
  - charging voltage and current are system-dependent, so standardisation is required
  - charging cables with energy and control cores
  - due to the use of DC, sophisticated protection measures are necessary, e.g. insulation monitoring

*) The voltages listed refer to the standards IEC 61851 and IEC 62196. In Germany the nominal voltages are 230 V / 400 V.

Considering the typical values for current and voltage applicable in Germany, the typically used power classes 3.7, 11, 22 and 43 kW apply to AC charging and the power classes 10, 20, 50, 100 150, 200 and 350 kW, respectively, apply to CD charging. The technical connection requirements for AC and DC charging stations are specified in VDE-AR-N 4102.

Suggestion 4.4.3

Fundamental technical framework conditions for the wireless charging of electric vehicles (there are several physical possibilities for wireless charging, but the present German Standardisation Roadmap for Electromobility focuses on inductive charging) are currently developed as part of several funded projects. From a current point of view, well-grounded standardisation suggestions can only be made on the basis of the results of these projects. The German standpoint with respect to standardisation project IEC 61980-1 ("Electric vehicle wireless power transfer system") with status FDIS must be coordinated between the different groups. A continuous and active involvement of

Suggestion 4.4.3 (continued)

German experts also at an international level must be aimed especially for the projects IEC/TS 61980-2 and -3 in order to avoid the premature specification and standardisation of technical solutions, which would inhibit technical progress and limit the variability of good solutions.

It must be ensured that the contents of ongoing international projects on inductive charging are harmonised. In this context, the ongoing projects IEC 61980, ISO PAS 19363 ("Electrically propelled road vehicles – Magnetic field wireless power transfer – Safety and interoperability requirements") and ISO 15118 ("Road vehicles – Vehicle to grid communication interface") must be considered.

4.4.1 AC charging

Alternating current charging stations in accordance with IEC 61851-1 and -22 are comparatively simple and inexpensive. They can be designed either as single-phase charging stations (alternating current) or three-phase charging stations. Only a slight additional effort is required to achieve three times as much power with the same current using a charging station with a three-phase AC connection. Figure 17 shows a possible block diagram of a public conductive charging station.

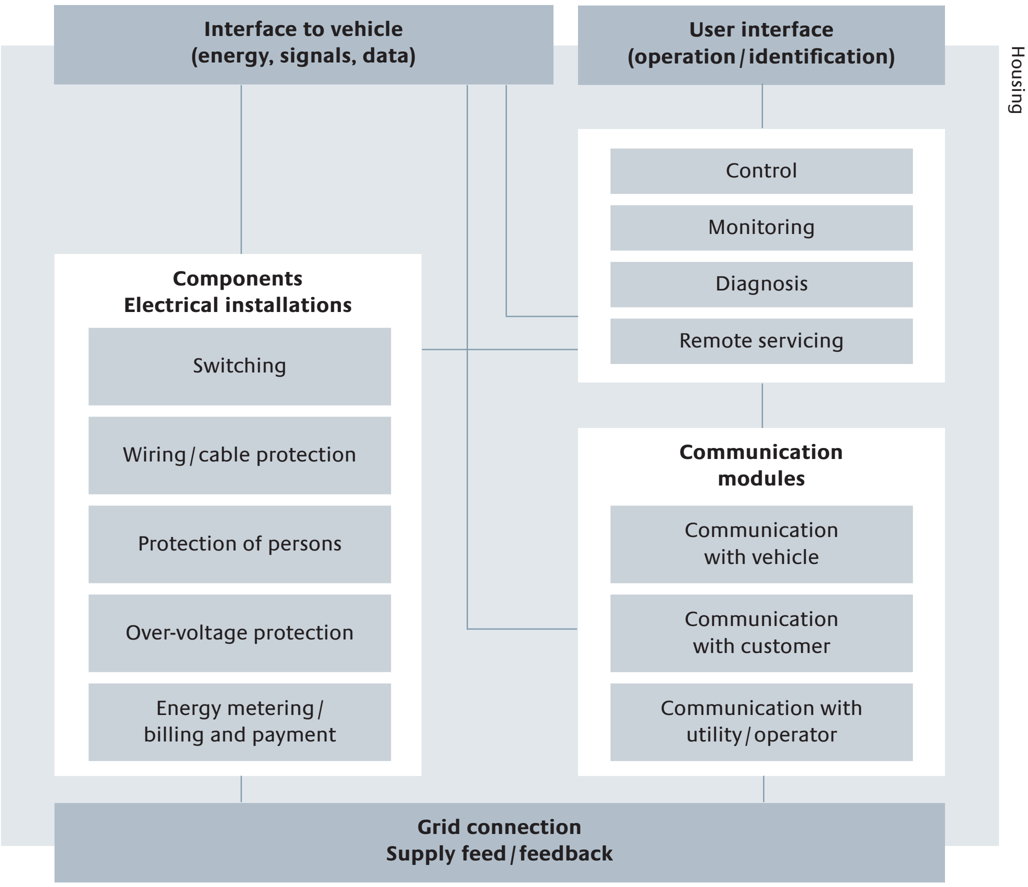


Figure 17: Block diagram of a public station for the conductive AC charging of electric vehicles (schematic)

Depending on its location and the charging modes, a charging station must support different combinations of functions and meet various requirements. The following aspects in particular need to be taken into consideration:

1. **Energy flows**
   - provision
   - load management (smart grid)
   - energy feedback into into the grid
2. **Control/safety**
   - pilot signal
   - plug interlock
   - disconnecting, switching and protection
3. **Communications**
   - access permission
   - billing ("metering")
   - user interface
   - energy feedback into the grid
   - load management (smart grid)
4. **Accessibility**
   - The applicable standards are to be observed
5. **Value-added services**
   - Work on framework conditions is still required

The standardisation project IEC 62752 "In-Cable Control and Protection Device for mode 2 charging of electric road vehicles (IC-CPD)" initiated by Germany currently has the status CDV and should be pursued and concluded under German management. **Suggestion 4.4.1.1**

4.4.2 DC charging

In designing the DC charging infrastructure, a more centralised approach that assumes that "supervised" charging is the most common practice is being taken which helps protect stations against vandalism. So-called "DC wall boxes" that offer combined AC and DC charging are also being considered as private premium or vehicle fleet solutions.

From a technical aspect, DC charging systems can be further classified into controlled and uncontrolled systems, as well as into galvanically isolated or galvanically coupled systems, according to the control technology used. In a controlled system, the DC charging station supplies just the voltages and currents that are required to power the vehicle's on-board systems (and therefore for charging the battery) according to the set points for the respective vehicle. In contrast to uncontrolled systems in which the DC charging station provides a certain constant voltage, additional voltage conversion in the vehicle is not required.

Present discussion tends to favour galvanically isolated DC charging stations. These enable the optimisation and technical simplification of the entire system comprising both the station and the vehicle. At the same time, only the development of controlled systems is being pursued so that the advantages of DC charging can be fully exploited, since the charging equipment will be in the stationary infrastructure instead of inside the vehicle.

Suggestion 4.4.2.1	As part of a revision of IEC 61851-23, a reference to the safety group standard DIN EN 62477-1 (VDE 0558-447-1) should be included.

4.4.3 Inductive charging

Resonant induction charging (inductive charging) is described in the German application rule (VDE AR-E 2122-4-2) which was published in March 2011. This rule describes key technical data and protection objectives. At an international level, the standards series IEC 61980 is under development. An SAE Task Force has also been in existence since the end of 2010. Both of these bodies also use the aforementioned German application rule.

In the German application rule, resonant induction charging is described as wireless charging without kinematic control mechanisms designed to provide good ergonomics and accessibility. Due to developing investigations, solutions with mechanical adjustment are being discussed. The field strengths used are kept to such a low level that none of the globally accepted recommended limits are exceeded and there are no risks to health even after several hours of whole-body exposure.

Suggestion 4.4.3.1	Work at the IEC 61980 series must be promoted in such a way that the standardised regulations for safe inductive charging in the range of small and medium power rates are formulated and published by the end of 2015. Subsequently, the IEC 61980 series must be revised in such a way that the standardised regulations for safe and interoperable inductive charging in the range of small and medium power rates are formulated and published by the end of 2018.

4.4.4 Automatic connection methods

Systems for the automatic connection of the vehicle plug combine the advantages of cabled and inductive charging methods.

Existing technical systems are currently in a research and testing phase. First results already show that inexpensive systems with high conformity with the existing standards can be generally realised.

General suggestion	It is recommended that the processes after a successful automatic connection comply with the fundamental safety and communication requirements of the standards ISO 17409 and IEC 61851.

Suggestion 4.4.4.1	IEC 61851 must be complemented with the topology description (special case of connection method “case C”). Furthermore, cancellation conditions and procedures for interruption influences during the connection process must be defined for the personal, machine, vehicle and environmental safety.

General suggestion

Standards for wireless authorisation and authentication (AA) as well as for the locating and positioning of the electric vehicle must be implemented in order to implement interoperable systems. In particular, synergies with the guidelines for inductive systems (IEC 61980 and ISO 1936) which are currently being prepared as well as wireless communication according to ISO 15118-6 can be formed in this context. This also applies for the positioning of the vehicle interface in analogy with the pick-up truck, if a floor-facing installation is intended.

The results of IEC strategy group 07 in the area of "Service Robots" can be used as a starting point to derive safety requirements for the connection module.

Due to the great harmonisation requirements for the standardisation of the plug connections, the use of the existing plug connection according to IC 62196 seems practical. The plug connections must be modified with uniform recognition labels (active or passive) in order to establish an interoperable regulation for the connection procedure.

4.4.5 Overview of system approaches

Figure 18 shows the various system approaches and sub-variants, as well as their relationship to the charging modes and plug variants.

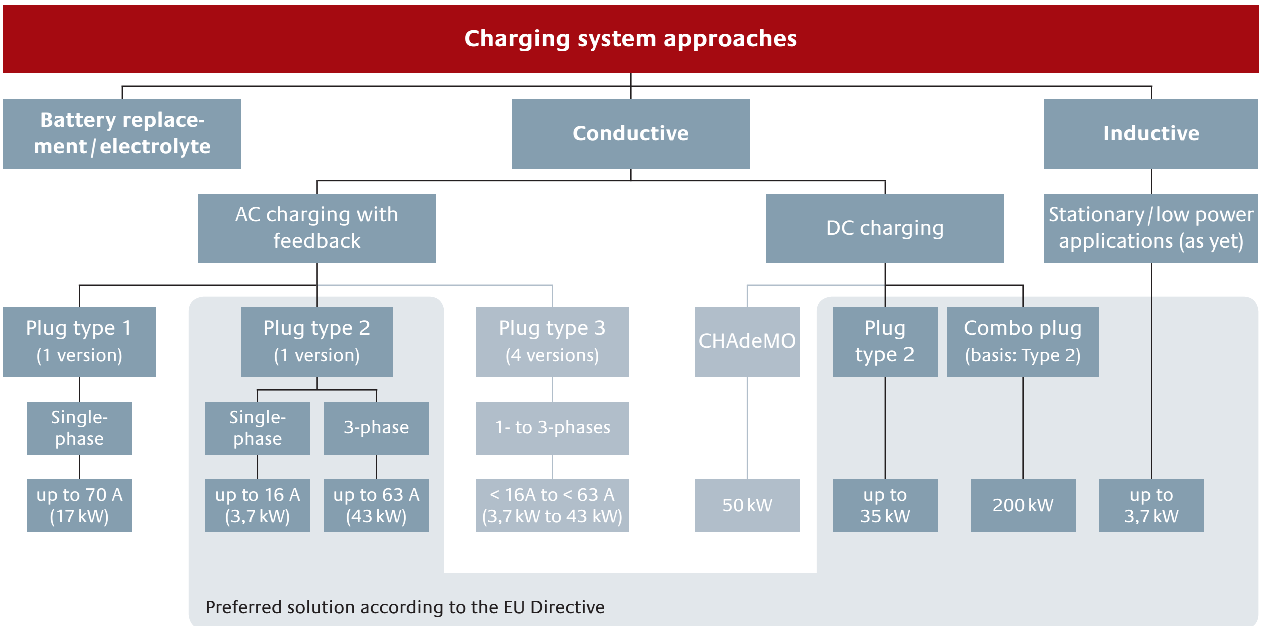


Figure 18: Overview of charging system approaches

To enable the rapid introduction of an interoperable charging infrastructure, it is recommended that the following priorities should be set for Germany:

- Priority 1:
  - AC charging: conductive AC charging (modes 1 to 3) with up to 63 A/44 kW three-phase (mode 3). In addition, charging mode 3 permits feedback of energy into the grid, thus providing optimum integration of renewable energy sources.
  - DC charging: charging power of over 50 kW is expected in the future (charging powers up to 100 kW and perspectively up to 350 kW can be expected).
- Priority 2: Inductive charging (resonant induction charging) at lower powers, for ease of operation.
- Priority 3: Battery switching or redox-flow batteries.

General suggestion

Mode 1 possible according to IEC 61851 requires the provision of an RCD in the infrastructure. However, energy suppliers and grid operators do not recommend its use because it cannot always be ensured that a protective earth conductor and RCD are available in household installations, and the consumer cannot check this in every case.

For existing installations, it is recommended that mode 2 is used, as the IC-SPD provides the required safety.

Mode 3 is recommended for new installations. Technically, mode 3 offers the option of direct load management via the charging interface, including the option of feeding energy back into the grid, and thus fulfils a necessary condition for linking electric vehicles to the smart grid. Furthermore, only the plug locking mechanisms in mode 3 prevent unauthorised access, thus simplifying unsupervised charging in public spaces. DIN VDE 0105-100 is already applied in this area, which is related to a repeated inspection.

Various charging stations (e.g. private, public, indoors, outdoors) and the resulting diverse requirements (e.g. over-voltage protection, etc.) will have to be taken into consideration for the various types of charging station. Repeated inspection of the electrical installation in the private sector is suggested irrespective of the additional load due to the loading of EVs.

Table 2 gives a summary of the main standards and specifications for the different system approaches.

China and Israel initiated the project for the development of the IEC 62840 series "Electric vehicle battery swap system" for battery swap systems. The work is reflected at a national level in the DKE group DKE/AK 353.0.7.

4.4.6 Charging plug components for electromobility

AC accessories
Provisions for the plug and socket configurations required for conductive energy transmission between the charging station and the electric vehicle are standardised by IEC/SC 23H in the standards series IEC 62196.

In the opinion of the German industry, ACEA (European Automobile Manufacturer’s Association) and a number of other countries, the use of the charging plug type 2 according to IEC 62196-2 (the German suggestion for plug standardisation) is recommended strongly for vehicles and infrastructure in Europe and other markets with three-phase supply. **Suggestion 4.4.6.1**

The face of plug type 2 according to the EU directive for AC charging (standard 62196-2) is depicted in Figure 19.

Figure 19: Plug type 2 from standard 62196-2

Configuration type 2 was proposed by Germany for both the vehicle side and infrastructure side and has the following characteristics:

- one to three phases
- max. current: 63 A (three-phase AC) and 70 A (DC and single-phase AC)
- max. voltage: 480 V
- compatible with combo plug accessories for DC charging up to 200 A

In addition, plug type 1 suggested by Japan will be available during a transition phase until 2017 on the vehicle side and has the following characteristics:

- single-phase
- max. current: 32 A
- max. voltage: 250 V (AC)

DC accessories

Suggestion 4.4.6.2

The DC charging plug is standardised at IEC/SC 23H as part 3 of the standards series IEC 62196. Germany suggested for this project to expand the AC plug type 2 for DC charging to a CCS. The couplers according to CCS are recommended for DC charging by the German industry and ACEA. Thanks to the system topology, all configurations conceived for AC applications can be used with the CCS (types 1 and 2 in particular). The USA and other countries must be convinced of the advantages of CCS as universal solutions for both DC and AC charging.

In IEC 62196-3, the couplers associated with the combined charging system are referred to as configuration EE and FF and include not only types 1 and 2 (IEC 62196-2) but also the Combo 1 and Combo 2 which have been designed for conducting larger currents of up to 200 A. Figure 15 shows the configuration C couplers within the CCS.

The face of plug Combo 2 according to the EU directive for DC charging (standard 62196-3) is depicted in Figure 20.

Figure 20: Plug Combo 2 from standard 62196-3

Charging cable: Application guide VDE-AR-E-2283-5 was developed by AK 411.28 for the German market and published on 01/07/2012. On this basis, standardisation applications will be submitted at a European and international level and will be further developed by IEC TC 20 into the future standards series IEC 62893 "Charging cables for electric vehicles".

Performance and consumption characteristics: Idle current consumption and efficiency

Reduction of the charging station's own energy consumption is an important issue for all charging methods. This also applies to the energy consumed while the station is in standby mode.

It is recommended to define regulations for the admissible energy consumption of the charging infrastructure, especially during periods in idle state. Similar to regulations for household appliances (e.g. TV sets), the energy consumption of non-active home charging boxes could be limited to 1 watt, or to 5 watts for public charging facilities.

Suggestion 4.4.6.3

Permitting the charging station to switch to an idle state in which it consumes less energy and from which it can be awakened either via the mains or via the vehicle connection is feasible and is on the planning agenda.

This is an essential precondition for controlled charging and demand-based electrical energy supply to vehicles, since this energy is not just used to charge the traction battery but also supplies power to all the electrical consumers in the vehicle while it is connected to the mains. This is the only way of realising a large variety of additional functions and services which would otherwise not be feasible without an external energy supply due to limited battery capacities.

In the case of DC charging and inductive charging, optimisation of efficiency by reducing high losses during charging processes is a significant aspect. While such optimisation can be achieved by suitable circuit design measures in DC charging systems, the system efficiency of wireless energy transmission plays an additional role for inductive charging methods. In this context, the availability of parking assistance functions for the precise positioning of the vehicle has to be taken into consideration when discussing the efficiency levels.

4.4.7 Safety requirements

Safety requirements have to be met under normal conditions (even under different climatic conditions), taking into consideration all foreseeable operating errors, misuse, accidents and vandalism.

Electrical safety

The following standards from the field of electrical installations must be observed in order to ensure protection against electric shock and thermal effects:

- DIN EN 61140 (VDE 0140-1):2007-03
  Protection against electric shock – Common aspects for installation and equipment (IEC 61140: 2001 + A1:2004, modified)
- DIN IEC/TS 60479-1 (VDE 0140-479-1):2007-05
  Effects of current on human beings and livestock – Part 1: General aspects (IEC/TS 60479-1:2005 + Corrigendum October 2006)

- DIN VDE 0100-540 (VDE 0100-540):2007-06
  Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors (IEC 60364-5-54: 2002, modified)
- DIN VDE 0100-410 (VDE 0100-410):2007-06
  Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock (IEC 60364-4-41: 2005, modified)
- DIN VDE 0100-530 (VDE 0100-530)
  Low-voltage installations – Part 530: Selection and erection of electrical equipment – Switchgear and control gear
- DIN VDE 0100-722
  Low-voltage installations – Part 7-722: Requirements for special installations or locations – Supply of electric vehicle
- Standards series IEC 61851
  “Electric vehicle conductive charging system”

Suggestion 4.4.7.1

Standard DIN 0100-722 was published according to plan at first at a national level. The future standard IEC 60364-7-772 “Low-voltage electrical installations – Part 7-722: Requirements for special installations or locations – Supply of electric vehicles” is currently under development. These works must be concluded quickly and subsequently must be transferred into a new version of VDE 0100-722.

Respective standards for electric safety must be developed or revised for the direct connection (DC charging) of vehicles with battery voltages over 400 V. Alignment with standards from other application areas must be taken into account.

The standards series IEC 61851 is applied to the charging of electric road vehicles. Current revision works should be concluded quickly.

Electromagnetic compatibility (EMC)

The approaches that have been followed up to now are based on the assumption that electric vehicles constitute a quasi-static load. Modern, powerful charging processes (impulse charging, ramping), in particular, may lead to hitherto-neglected grid interference and stability problems, resulting in additional EMC stresses which need to be dealt with in standards.

EMC is only considered for the drive and overall system level – this includes the battery. Demand for activities is seen in conducting testing under defined load conditions and in adapting the requirements for immunity and the field strength to technological progress. In this context, EMC standards must also be considered that are dealt with in connection with CISPR. Part of these standards must be amended with new standard parts. Special features must be considered according to the vehicle category, e.g. in category M3. In particular, the standards IEC 61851-21-1 “Electric vehicle conductive charging system – Part 21-2 Electric vehicle onboard charger EMC requirements for conductive connection to an a.c./d.c. supply” and IEC 61851 21-2 “Electric vehicle conductive charging system – Part 21-2 EMC requirements for OFF board electric vehicle charging systems” must be concluded quickly. The activities of SC 77A/WG 8 on harmonic components in a range from 2 to 150 kHz must be followed further.

Suggestion 4.4.7.2

Furthermore, the following standards must be considered:

- DIN EN 61000-6-2 Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments
- DIN EN 61000-6-3 Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments

Functional safety

Process-oriented requirements for functional safety are standardised in IEC 61508, which has several application-specific deductions such as ISO 26262. It does not seem reasonable for the installation of charging stations in different locations (private, public, semi-public, indoors, outdoors) to supply the trade with a risk analysis to achieve required safety levels (SIL). The development of an instructing standard is recommended, for which a risk analysis is conducted by the standardisation body. Additionally, it must be examined whether instructing specifications and standards for the use of charging cables and charging stations is necessary.

Suggestion 4.4.7.3

Lightning protection and over-voltage protection

- It must be assumed that electric vehicles will be charged outdoors even during thunderstorms. Therefore, the subject of lightning protection and over-voltage protection must be taken into consideration for the overall vehicle-charging station-distribution grid system.
- During AC charging (charging modes 1 to 3 according to IEC 61851-1), over-voltage category II applies for the charging interface (socket or vehicle connector) according to the general regulations of IEC 60664 (insulation coordination). The risk of an external lighting strike (e.g. in the charging station or the vehicle) must be investigated an over-voltage protection must be provided for the crossover from lightning protection zone 0 (outdoor area) to lighting zone 1 (indoor area), if necessary. DKE/GAK 353.0.4 has been assigned to work on this problem and should consider this when revising IEC 61851-1. If necessary, DKE/GAK 353.0.4 should coordinate its activities with other bodies (e.g. DKE/UK 221.1).
- During DC charging, the (firmly connected) DC charging station must fulfil the over-voltage category at the mains connection according to IEC 60664-1. The requirements for the interface to the vehicle are described in IEC 61851-23. DKE/GAK 353.0.4

has been assigned to work on this problem and should consider this when revising IEC 61851-1. If necessary, DKE/GAK 353.0.4 should coordinate its activities with other bodies (e.g. DKE/UK 221.1) also in this case.

- The automotive industry designs its vehicles as over-voltage category II devices, the same category as for all other electrical equipment. If more extensive protective measures are found to be necessary, normal commercially available components can be used as surge arresters. No acute need for standardisation measures beyond the specifications of IEC 61851 are considered to be necessary.

Structural safety and security
Structural safety and security issues include requirements on the housing of the charging station with regard to the installation site, identification, signs, parking arrangement (optimum orientation/location of the charger column in relation to the parking area) and vandalism.

General suggestion

The IEC/TS 61439-7 describes structural requirements for housings of charging stations. Different charging systems (AC, DC, etc.) are considered in this specification. Furthermore, VDE-AR-N 4102 "Anschlussschränke im Freien am Niederspannungsnetz der allgemeinen Versorgung – Technische Anschlussbedingungen für den Anschluss von ortsfesten Schalt- und Steuerschränken, Zähleranschlussäulen, Telekommunikations-Anlagen und Ladestationen für Elektrofahrzeuge" (Connection boxes in outdoor areas connected to the low-voltage network of the general grid – Technical connection requirements for the connection of stationary switch and control boxes, meter connection columns, telecommunication devices and charging stations for electric vehicles) published in 2012 must be considered for the connection of charging stations to the public low-voltage grid.

Safe erection or extension of an electrical installation with a charging station
The German Niederspannungsanschlussverordnung (Low-Voltage Connection Regulation) stipulates that installers erecting or extending an electrical installation must be listed in the Installateurverzeichnis (installers registry) of a grid operator (see §13 of the Niederspannungsanschlussverordnung). The work is to be carried out by qualified electricians under the supervision of an electrician who bears responsibility for this work (DIN VDE 1000-10). The installation work must be executed by a specialist company registered in the Handwerksrolle (skilled trades register).

The general installation standards (VDE 0100 series of standards) govern the erection and extension work of electrical installations. In addition, special technical rules for the installation of charging stations are being developed by DKE/K 221 which will be published as EN 60364-7-722.

If the charging station is a new construction as part of a new electrical installation, it is to be ensured that the electrical installation will be designed so that it can sufficiently accommodate the charging station. Thus, the charging station is deemed a device within the meaning of the Low-Voltage Directive that is part of the electrical installation.

Installing a permanently connected charging station into an existing infrastructure is regarded as an extension of the electrical installation. Before an existing electrical installation can be extended, its suitability for the extension has to be verified. Since installing a charging station changes the operating conditions, this frequently nullifies the status quo, the “Bestandsschutz”, of the installation. If the inspection of the respective electrical installation shows that the existing installation is not capable of supporting the charging station, the necessary safety-relevant modifications must be made to the installation in order to ensure continued safe operation.

Operational safety

The number of electrical consumers connected to an installation by means of plugs (e.g. dishwashers, microwave ovens, dryers etc.) has been continually increasing over the past years and decades. Likewise, the number of distributed power plants connected to the electric grid (e.g. photovoltaics, micro-CHP plants) is also increasing.

Qualified inspection and testing are obligatory when an electrical installation is to be extended by a charging station. If the inspection shows that additional safety measures are needed, the electrical installation must be upgraded accordingly. As an example, however, when an electric vehicle is charged in mode 1 (without RCD) using an existing household mains outlet (mains outlet with protective earth contact) an RCD in the household installation is indeed obligatory, but is not always present. Apart from this, existing household mains outlets typically used for charging (e.g. in garages or outdoors) are not designed for charging vehicles in continuous operation.

For the aforementioned reasons, the requirement that existing systems be inspected and tested is justified. Whether and how frequently an existing electrical installation is to be inspected and what measures are required is to be specified based on safety-related criteria.

If the technical requirements for newly-built charging stations ensure their intrinsic safety, then no inspection is required. Suitable information regarding this is to be provided when the charging station is handed over to the operator.

Suggestion 4.4.7.4

At present, there are no adequate technical rules that permit a differentiated assessment as to whether and how frequently an existing electrical installation is to be inspected. Normative foundations should be developed for this purpose. In doing so, the special characteristics of the electromobility charging infrastructure must be considered. Furthermore, it must be examined whether the development of safety instructions should be supported with specifications and standards for the installation and maintenance of the charging infrastructure. DIN VDE 0105-100 deals with safe operation and periodic inspection. However, the standard must be revised concerning its scope of application.

Appliances that can be operated by the general public are necessary for the charging of electric vehicles and special measures must be taken to deal with the associated hazards. In this context, particular attention is to be paid to the following aspects:

- Transmission of large amounts of power with the associated high currents, high voltages and high energy density.
- Frequent use by the general public who are less able to recognise acute hazards. There is a risk that the respective installation might be tampered with or vandalised, which could lead to severe damage and/or injury.
- Frequent user changes, various kinds of user behaviour and intensive utilisation (e.g. continuous charging operation, charging cables are plugged/unplugged frequently) as well as varying environmental conditions (enclosed spaces, outdoors, in urban areas, in rural areas, weather conditions etc.) all affect wear and tear.
- As regards safety, both the mains voltage and the on-board voltage need to be taken into account.
- Suitable protection concepts must be drawn up to allow for the fact that arcing may occur during DC charging procedures.
- There is a demand for high availability and reliability.
- There are different regulations regarding the operation of systems in private areas, in public spaces and on commercial premises.

4.4.8 Current charging station standardisation activities

Table 2 below gives an overview of the most important standards for charging stations and Figure 21 shows the status of the most important standards projects on charging stations.

Table 2: Overview of current main standards proejects applicable to charging stations, August 2014

Designation	Subject/title	Status
IEC 60364-7-722	Low-voltage electrical installations – Part 7-722: Requirements for special installations or locations – Supply of electric vehicles	CDV
IEC 61000-6-2 Edition 3	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments	CD
IEC 61140 Edition 4 (VDE 0140-1)	Protection against electric shock – Common aspects for installation and equipment	CDV
IEC 61850-7-420 Edition 2	Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Distributed energy resources logical nodes	AMW
IEC 61851-1 Edition 3	Electric vehicle conductive charging system – Part 1: General requirements	CD
IEC/TS 61851-3-1	Electric Vehicles conductive power supply system – Part 3-1: General Requirements for Light Electric Vehicles (LEV) AC and DC conductive power supply systems	CD

Designation	Subject/title	Status
IEC/TS 61851-3-2	Electric Vehicles conductive power supply system – Part 3-2: Requirements for Light Electric Vehicles (LEV) DC off-board conductive power supply systems	CD
IEC/TS 61851-3-3	Electric Vehicles conductive power supply system – Part 3-3: Requirements for Light Electric Vehicles (LEV) battery swap systems	ANW
IEC/TS 61851-3-4	Electric Vehicles conductive power supply system – Part 3-4: Requirements for Light Electric Vehicles (LEV) communication	ANW
IEC 61851-21 Edition 2	Electric vehicle conductive charging system – Part 21: Electric vehicle requirements for conductive connection to an a.c./d.c. supply	CD
IEC 61851-21-1	Electric vehicle conductive charging system – Part 21-1: Electric vehicle onboard charger EMC requirements for conductive connection to a.c./d.c. supply	CD
IEC 61851-21-2	Electric vehicle conductive charging system – Part 21-2: EMC requirements for OFF board electric vehicle charging systems	CD
IEC 61851-23 Edition 2	Electric vehicle conductive charging system – Part 23: DC electric vehicle charging station	NP
IEC 61851-24 Edition 2	Electric vehicle conductive charging system – Part 24: Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging	NP
IEC 61980-1	Electric vehicle wireless power transfer systems (WPT) – Part 1: General requirements	FDIS
IEC/TS 61980-2	Electric vehicle wireless power transfer (WPT) systems – Part 2: Specific requirements for communication between electric road vehicle (EV) and infrastructure with respect to wireless power transfer (WPT) systems	ANW
IEC/TS 61980-3	Electric vehicle wireless power transfer (WPT) systems – Part 3: Specific requirements for the magnetic field power transfer systems	ANW
IEC 62196-2 Edition 2	Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories	CD
IEC/TS 62196-4	Plugs, socket-outlets, and vehicle couplers – Conductive charging of electric vehicles – Part 4: Dimensional compatibility and interchangeability requirements for a.c., d.c. and a.c./d.c. vehicle couplers for Class II or Class III light electric vehicles (LEV)	ANW
IEC 62660-3	Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 3: Safety requirements of cells and modules	CD

Designation	Subject/title	Status
IEC 62752	In-Cable Control and Protection Device for mode 2 charging of electric road vehicles (IC-CPD)	CDV
IEC 62831	User identification in Electric vehicle Service Equipment using a smartcard	ANW
IEC 62840-1	Electric vehicle battery swap system – Part 1: System description and general requirements	CD
IEC 62840-2	Electric vehicle battery swap system – Part 2: Safety requirements	CD
IEC 62893	Charging cables for electric vehicles	ANW
23E/853/NP	Residual Direct Current Monitoring Device to be used for Mode 3 charging of Electric Vehicle (RDC-MD)	ANW
ISO 15118	Road vehicles – Vehicle to grid communication interface ➜ see Table 1	

Note: Other relevant standards relating to electromobility are listed in Table 1.

Charging technologies

Standards		NP	CD	CDV	FDIS	IS
IEC 61851-1 Ed. 3: Electric vehicle conductive charging system General requirements						2015
IEC/TS 61851-3-1 EV conductive power supply system General Requirements for LEV AC and DC conductive power supply systems	new					2017
IEC/TS 61851-3-2 EV conductive power supply system – Requirements for LEV DC off-board conductive power supply systems	new					2017
IEC/TS 61851-3-3 EV conductive power supply system Requirements for LEV battery swap systems	new					2017
IEC/TS 61851-3-4 EV conductive power supply system Requirements for LEV communication	new					2017
IEC 61851-21-1 EV conductive charging system EV onboard charger EMC requirements for conductive connection to a.c./d.c. supply						2015
IEC 61851-21-2 EV conductive charging system EMC requirements for OFF board EV charging systems						2015
IEC 61851-23 Ed. 2: EV conductive charging system DC EV charging station	new					2017
IEC 61851-24 Ed. 2: EV conductive charging system Digital communication between a d.c. EV charging station and an EV for control of d.c. charging	new					2016
IEC 61980-1 Electric vehicle wireless power transfer systems (WPT) General requirements						2015
IEC/TS 61980-2 EV WPT systems Specific requirements for communication between EV and infrastructure with respect to WPT systems	new					2017
IEC/TS 61980-3 EV WPT systems – Specific requirements for the magnetic field power transfer systems	new					2017
IEC 62752 In-Cable Control and Protection Device for mode 2 charging of electric road vehicles (IC-CPD)						2015
Standards		NP	CD	CDV	FDIS	IS

NP New Work Item Proposal
CD Committee Draft
CDV Committee Draft for Vote
FDIS Final Draft International Standard
IS International Standard
EV Electric Vehicle
LEV Light Electric Vehicle
WPT Wireless Power Transfer

Phase completed

Phase not completed

	Standards	NP	CD	CDV	FDIS	IS
Other	**IEC 60364-7-722** Low voltage electrical installations – Requirements for special installations or locations – Supply of EV					2015
	IEC/TS 61439-7 Low-voltage switchgear and controlgear assemblies – Assemblies for specific applications such as marinas, camping sites, market squares, EV charging stations					Published
	IEC 62196-1 Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of EV General requirements					Published
	IEC 62196-2 Ed. 2: Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of EV – Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories					2015
	IEC 62196-3 Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of EV – Dimensional compatibility and interchangeability requirements for d.c. and a.c./d.c. pin and contact-tube vehicle couplers					Published
	IEC/TS 62196-4 Plugs, socket-outlets, and vehicle couplers Conductive charging of EV – Part 4: Dimensional compatibility and interchangeability requirements for a.c., d.c. and a.c./d.c. vehicle couplers for Class II or Class III light electric vehicles (LEV)					2017
	IEC 62831 User identification in EV Service Equipment using a smartcard					2017
	IEC 62893 new Charging cables for EV					2017
	23E/853/NP new Residual Direct Current Monitoring Device to be used for Mode 3 charging of EV (RDC-MD)					2017
	Standards	NP	CD	CDV	FDIS	IS

NP	New Work Item Proposal
CD	Committee Draft
CDV	Committee Draft for Vote
FDIS	Final Draft International Standard
IS	International Standard
EV	Electric Vehicle
LEV	Light Electric Vehicle
WPT	Wireless Power Transfer

Phase completed

Phase not completed

Figure 21: Status of the main standardisation projects on charging stations, August 2014

5 Prospects for the Future

This section lists aspects that are not required pre-requisites for the introduction of electromobility (market launch) according to a present assessment of expert groups. However, they may become relevant in future technology and market scenarios.

The currently discussed topics on the re-use of degraded batteries, feedback into the grid, communication, uniform voltage level, inductive charging while the vehicle is moving and battery recycling are presented in more detail.

- **Re-use of degraded batteries**
  The idea of using degraded ("second life") batteries as stationary buffer batteries (e.g. for wind and solar energy) is currently being discussed, and research is being carried out on this subject. The standardisation of performance characteristics, diagnostic signals (e.g. temperature signals) and thermal requirements (cooling/heating) may have a positive effect on such applications and the corresponding business models. A cooperation of the respective groups, especially DKE/EMOBILITY.50, should be aimed for over the medium-term
- **Energy feedback into the grid**
  There are two types of energy feedback:
  - feeding back energy to bridge periods in which solar or wind generators do not provide sufficient energy to meet the current demand,
  - feeding back energy to stabilise the grid in order to balance out short-term fluctuations until other power stations can be started up and synchronised with the grid.

  These two approaches are physically similar, but stabilisation feedback tends to be a brief, short-term service, whereas real energy feedback would mean providing energy for several hours. The technical, economic and customer-related framework conditions required to implement these two variants still have to be investigated.
- **Communications**
  ETSI is currently working in close cooperation with the CAR 2 CAR Communication Consortium on the standardisation of short-range car-to-car and car-to-infrastructure communications on the basis of the IEE 802.11p standard. In this context, the possibility of communications with electric vehicle charging stations is under discussion, whereby it is especially important to ensure that there are no contradictory provisions with respect to billing/payment systems, safety and data privacy.
- **Standardised voltages**
  Standardised voltages allow economies of scale in development and production and therefore support market penetration, particularly during the growth phase and ensuing periods. Based on experiences gained during the introduction phase, the standardisation of several discrete voltage levels should be considered.
- **Inductive charging while the vehicle is moving**
  Inductive charging while the vehicle is moving may play a certain role in future (e.g. for buses travelling on tram lanes). Technical aspects and the economic feasibility are currently the subject of controversial debate.
- **Recycling batteries**
  Standardised calculations of recycling efficiency and the restoration rate with widely accepted units is required for the recycling of batteries.

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Annex B Terms and abbreviations

For the purposes of this document, the following terms and definitions and abbreviations apply.

B.1 Terms and definitions

B.1.1 Electric vehicle

For the purposes of the German Standardisation Roadmap for Electromobility, the term “electric vehicle” refers to any vehicle that is fully or partially propelled by an electric motor.

- battery-operated electric vehicles
- switchable battery-operated electric vehicles
- fuel cell-operated electric vehicles
- plug-in hybrid electric vehicles
- non-chargeable hybrid electric vehicles
- redox-flow electric vehicles

B.1.2 Electromobility

Electromobility refers to the use of electric vehicles for various transport needs.

B.1.3 Vehicle categories

Categorisation of vehicles in categories M and N according to the European Directive 2007/46/EG:

Category M	Motor vehicles with at least four wheels designed and constructed for the carriage of passengers.
Category M1	Vehicles designed and constructed for the carriage of passengers and comprising no more than eight seats in addition to the driver’s seat.
Category M2	Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver’s seat, and having a maximum mass not exceeding 5 tonnes.
Category M3	Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver’s seat, and having a maximum mass exceeding 5 tonnes.
Category N	Motor vehicles with at least four wheels designed and constructed for the carriage of goods.
Category N1	Vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes.
Category N2	Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3.5 tonnes but not exceeding 12 tonnes.
Category N3	Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 12 tonnes.

Categorisation of vehicles in class L according to the criteria of the Directive (EU) No. 168/2013:

Category L	Two or three-wheel vehicles and light quadricyles
L1e	Light two-wheel powered vehicle
L2e	Three-wheel moped
L3e	Two-wheel motorcycle
L4e	Two-wheel motorcycle with side-car
L5e	Powered tricycle
L6e	Light quadricycle
L7e	Heavy quadricycle

B.1.4 Categorisation of vehicles in category M and L

Category	Range [km/day]	Vehicle categories	Energy demand [kWh/km]	Charging duration Night charging/ fast charging	Service life [a]
Regular service	< 300	M1, M2, M3, N1, N2	approx. 1,5–2,5	8 h / 10 min	> 12
Distribution traffic	< 150	N1, N2, N3	approx. 1,0–1,5	8 h / 15 min	> 8
Long-distance traffic	> 500	M3, N3	approx. 0,8	8 h / 60 min	> 8

B.1.5 High voltage

Voltage class B: greater than 30 V (AC) up to and including 1,000 V (AC), and greater than 60 V (DC) up to and including 1,500 V (DC) (see ISO 6469-3).

Note: For clarity's sake this text does not refer to "high-voltage on-board networks" but to "voltage class B on-board networks".

B.1.6 Charging mode

The charging mode describes the method by which the electric vehicle is charged. The various modes are differentiated by the power range for energy transmission and safety characteristics. The four charging modes defined in IEC 61851 and a further mode that is currently under discussion are described in section 4.4.

B.1.7 Charging station (electric power supply for electric vehicles)

A charging station refers to equipment according to IEC 61851 used for charging electric vehicles, the main elements of which are the connecting elements, line protection, an RCD, a circuit breaker and a safety communication device (PWM). Depending on the place of use, other functional units may be included, such as a connection to the supply mains and metering devices.

The terms “AC charging station for electric vehicles” and “DC charging station for electric vehicles” are defined in DIN EN 61851-1 (VDE 0122-1). The term “charging station” is therefore also used as a generic term in the German Standardisation Roadmap for Electromobility and applies to ÀC and DC charging as well as to inductive charging.

B.1.8 Plug-and-socket connection system, cable assembly

Plug-and-socket assembly provided for charging electric vehicles. The IEC 62196 series describes a plug-and-socket system intended especially for electric vehicles.

For charging modes 2 and 3 a hybrid cable with an energy core and control lines is also necessary.

B.1.9 Definition of the combined charging system (CCS)

The CCS is an open, universal charging system for electric vehicles based on the international standards series IEC 61851-1 and the standards for plug-and-socket connections according to IEC 62196. The CCS combines single-phase charging to three-phase charging (up to 200 kW and perspectively up to 350 kW) in a single system. As a system, the CCS contains plugs as well as control functions and the communication between the electric vehicle and infrastructure. It offers a solution for all required charging scenarios.

In general, the CCS contains:

- DC charging with Combo 2 plug (in Europe) according to standard IEC 62196-3 together with communication between the vehicle and charging infrastructure based on ISO 15118 and/or DIN SPEC 70121
- AC charging with type 2 plug (in Europe) according to standard IEC 62196-2 together with communication between vehicle and charging infrastructure with signalling (pilot signal) according to IEC 61851-1 Annex A and, optionally, also according to ISO 15118

It must be taken into account that the possibilities described above are not supported by all charging stations and all vehicles. The combined charging system on the vehicle side is part of a CCS system. Thus, the customer has access to all AC type 2 and DC type 2 charging facilities.

B.2 Abbreviations

ACEA	Association des Constructeurs Européens d'Automobiles (European Automobile Manufacturers Association)
AK	Arbeitskreis (working group)
ANSI	American National Standards Institute
AMW	Approved Maintenance Work
ANSI EVSP	ANSI Electric Vehicles Standards Panel
ANW	Approved New Work
AWI	Approved Work Item
BATSO	Battery Safety Organisation
BEV	Battery Electric Vehicle
BMBF	Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research)
BMUB	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Environment Ministry)
BMVI	Bundesministerium für Verkehr und digitale Infrastruktur (Federal Ministry of Transport and Digital Infrastructure)
BMWi	Bundesministerium für Wirtschaft und Energie (Federal Ministry of Economic Affairs and Energy)
BSI	Bundesamt für Sicherheit in der Informationstechnik (Federal Office for Information Security)
CCS	Combined Charging System
CEN	Comité Européen de Normalisation (European Committee for Standardisation)
CENELEC	Comité Européen de Normalisation Électrotechnique (European Committee for Electrotechnical Standardisation)
CD	Committee Draft
CDV	Committee Draft for Vote
CHAdeMO	CHArge de MOve – Japanese suggestion for a DC plug
CISPR	Comité International Spécial des Perturbations Radioélectriques (International Electrotechnical Commission)
CoP	Conformity of Production
DIN	German Insititute for Standardisation
DIN SPEC	DIN Specification
DIS	Draft International Standard
DKE	Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE (German Commission for Electrical, Electronic and Information Technologies of DIN and VDE)
DNS	Deutsche Normungsstrategie (German Standardisation Strategy)
eM-CG	CEN / CENELEC eMobility Coordination Group
EMC	Electromagnetic Compatibility
EN	European Standard
EnWG	Energiewirtschaftsgesetz (Energy Industry Act)
EPAC	Electric Power-Assisted Cycles
ETSI	European Telecommunications Standards Institute
Euro NCAP	European New Car Assessment Programme
EV	Electric Vehicle

EVU	Energieversorgungsunternehmen (German for "power supply company")
FCEV	Fuel Cell Electric Vehicle
FDIS	Final Draft International Standard
FNN	Forum Network Technology/Network Operation at VDE
GAK	Gemeinschaftsarbeitskreis (joint working group, see JWG)
GK	Gemeinschaftskomitee (joint committee, see JTC)
GUK	Gemeinschaftsunterkomitee (joint subcommittee)
HD	Harmonisation document
HV	High-Voltage
IC-CPD	In-Cable Control and Protection Device
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ICT	Information and Communication Technology
IP	Internet Protocol
IS	International Standard
ISO	International Organisation for Standardisation
ITA	Industry Technical Agreement
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardisation Sector
JTC	Joint Technical Committee
JWG	Joint Working Group
LEV	Light Electric Vehicle
MoU	Memorandum of Understanding
NA	Normenausschuss (standards committee)
NP	New Project (ISO)
NP	New Work Item Proposal
NPE	National Platform for Electromobility
NOW	Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie (National Organisation Hydrogen and Fuel Cell Technology)
PAS	Publicly Available Specification
PCI DSS	Payment Card Industry Data Security Standard
PCI SSC	Payment Card Industry Security Standards Council
PHEV	Plug-in Hybrid Electric Vehicle
PLC	Power Line Communication
PT	Project Team
PTB	Physikalisch-Technische Bundesanstalt (Physical and Technical Institute of the Federal Republic of Germany)
PUB	Published
PWM	Pulse Width Modulation (Safety communication devices)
R&D	Research & Development
RCD	Residual Current Protective Device
REEV	Range Extended Electric Vehicle
RFID	Radio-Frequency Identification
SAE	Society of Automotive Engineers
SC	Subcommittee
SG	Secretary General

SIL	Safety Integrity Level
SME	Small and Medium-sised Enterprises
SMB	Standardisation Management Board (at IEC)
TAB	Technische Anschlussbedingungen (German technical connection conditions)
TCP/IP	Transmission Control Protocol / Internet Protocol
TMB	Technical Management Board
TR	Technical Report
UK	Unterkomitee (subcommittee)
UL	Underwriters Laboratories
US NCAP	US New Car Assessment Program
V2G	Vehicle to Grid – This term describes both the communications between the vehicle and the charging infrastructure as well as the energy flow from the vehicle to the grid. In this text, the respective context is always identified.
V2G CI	Vehicle to Grid Communication Interface
VDA	Verband der Automobilindustrie e. V. (German Association for the Automotive Industry)
VDE	Verband der Elektrotechnik Elektronik Informationstechnik e. V. (Association for Electrical, Electronic and Information Technology)
W3C	World Wide Web Consortium
WG	Working Group
WPT	Wireless Power Transfer
XML	Extensible Markup Language
ZVEH	Zentralverband der Deutschen Elektro- und Informationstechnischen Handwerke (German Association of Electrical and IT Trades)
ZVEI	Zentralverband Elektrotechnik- und Elektronikindustrie e. V. (German Association of the Electrical and Electronics Industries)

Annex C Benefits of electromobility for various interest groups

This Annex describes the benefits of electromobility for various interest groups by listing practical examples (the list is not exhaustive) and describing the effects of standardisation in each case.

C.1 Opportunities offered by electromobility

Opportunities for the state and society

Environmental advantages

- Noise emissions are lower at low and medium speeds and when accelerating, since rolling and wind noise will have less influence. These effects will be particularly noticeable in urban areas and on main thoroughfare roads.
- Direct emissions (exhaust gases) by road traffic are avoided. This has a positive effect particularly in urban areas and will contribute to improving the quality of life there.
- If the electrical energy for electromobility is provided by regenerative energy sources, the CO_2 emissions will be reduced considerably.
- Electromobility is a form of energy consumption that can be adapted, as needed, to the power currently available from regenerative energy sources, provided that consensus-based standards and specifications exist on load management and, possibly, feedback into the grid. Thus, the introduction of the smart grid supports electromobility and vice versa, and this in turn facilitates the achievement of climate policy goals.

Economic advantages

- Securing jobs in the automobile industry, creating new jobs.
- Creating new markets for automobile manufacturers, the chemicals industry, electrical engineering industry and the information and communications industry, as well as for energy utilities and mobility service companies.
- Establishing new business models.
- At present petroleum, as a raw material, is the main source of energy used in the transportation sector. In face of limited petroleum reserves (key topic: peak oil) and from the geo-political aspect, the objective is to obtain greater diversification of energy sources in order to ensure a sustainable energy supply. In this context, electromobility can make a valuable contribution all over Germany by providing large storage capacities for electricity as a form of energy that is independent of primary energy sources.
- Domestic tourism can profit from electromobility as the conflict between ease of access to a holiday destination, spa or recreational area and the wish for less traffic noise can be almost completely resolved.

Added value for the general public and consumers

Electromobility offers advantages to the general public, both as users of the vehicles and as residents of areas in the direct or indirect vicinity of roads.

- Less road traffic noise
- Reduction of exhaust gas emissions
- Long-term assurance of individual mobility
- For many people, the responsibility of maintaining a liveable environment for generations to come is a very important issue. In future, electromobility will give consumers one way of resolving this issue more satisfactorily.

The first two points mentioned above contribute to improved public health. Relevant studies [6], [7] have identified traffic noise as one of the main causes of stress.

Especially considering the expected increase, albeit moderate, in urban growth throughout Germany, electromobility can make a significant contribution to improving the quality of life.

Opportunities for the automobile manufacturing industry

- During the introduction phase (phase 1), electromobility will have a substantial effect on the image of car manufacturers. In this respect, the challenge facing the German automobile industry is to become the pioneer of a mature mass electromobility market.
- Securing shares in the market

Opportunities for component suppliers, the electrical industry, SMEs, trades and testing institutes

- A new high-tech field that spawns innovative products
- Sustainable product portfolio
- The charging infrastructure sector in particular is expected to provide considerable impetus for turnover and employment in small and medium-sised enterprises and in the electrical trade, as well as for retailers and wholesalers in Germany, since a large percentage of the added value is generated regionally.
- Suitable PR marketing measures can achieve synergy effects with other sectors such as smart meters and building automation (“smart homes”) which, in turn, also provide additional employment stimulus.

Advantages for grid operators

- Additional energy grid utilisation leads to additional earnings
- Electric cars as powerful consumers and possibly as storage units (for balancing local energy consumption) will propel discussion on smart grids, smart homes and smart metering.

Benefits for energy traders and electricity generating companies

Generally speaking, electromobility will bring new consumers onto the market, leading to increased electricity trade turnover. However, electromobility is also expected to encourage the substitution of oil, a limited resource, with electrical energy from alternative, especially regenerative, sources (hydroelectric, wind, biomass and photovoltaics), thus promoting the expansion of trading electricity from regenerative sources. The reason for this is that such a controllable mode of consumption can improve the integration of electricity from regenerative sources. Increased turnover is particularly expected in the time-variable tariff sector (demand-side management, smart metering). Collective integration of electric vehicles will mean that a new player who will have a positive market effect in terms of competition and supply reliability will enter the balancing energy market.

Opportunities for service providers
It is expected that the introduction of electromobility will lead to new service fields and to changes in existing service sectors. Defining new service fields is not one of the objectives of the German Standardisation Roadmap for Electromobility. However, some examples are described here to illustrate how standardisation can support the creation of new service sectors.

- The further dissemination of regenerative energy is expected to lead to more volatile electricity prices. Up to now, end consumers are hardly able to reap the benefits of electricity price variations. In this context, the services of "electricity traders" can help to adjust consumption (= charging of electric vehicle batteries) to match the electric energy supply.
- In present-day car financing practices, the resale value of the entire vehicle plays a major role. It is conceivable that the battery will be financed separately in future. The option of being able to put a battery to a secondary use ("second life", refurbishment or recycling of materials) has a significant effect on the remaining value of a used battery.
- New business opportunities arise for parking facility companies as they can offer combined parking and charging services. This applies similarly to the housing sector.
- Accounting and settlement (clearing) institutions.

Benefits for battery manufacturers
- Electromobility will generate additional demand.
- Traction batteries are complex systems and German manufacturers are well positioned in this field.
- German manufacturers may be able to catch up with their Asian competitors in the cell production sector.

Research opportunities
Further development of existing technologies such as power electronics, motor technology, battery technology and light-weight construction in conjunction with the development of electromobility is an exciting and lucrative field for German research institutions. The special requirements of electromobility with regard to weight reduction, stability, etc. will generate new research impetus that will lead to improvements in other areas as well. Achieving expertise in the electromobility field is therefore of special importance to German research and industry. The initiatives launched by government and industry give companies and institutes the opportunity to develop such expertise on a broad basis.

The development of innovative holistic concepts which can shape the future of mobility is of special scientific interest. Suitable topics might include mobility concepts for urban areas, for example, or the development of new vehicles taking a completely new approach to design, construction, materials and marketing.

Research institutions working in Germany have the opportunity to develop and exploit new research areas. Related topics in information and communications technology (ICT), in conjunction with energy and automotive engineering, are just some examples worth mentioning here. Since ICT solutions developed in this field will not remain restricted to the electromobility sector, one can assume that they will bring about further innovations in other sectors as well, in particular sectors related to the smart grid.

The research sector should see the feedback of research results to standards organisations and legislative bodies both as a task and as an opportunity, allowing this sector to have an influence on modifications to legislation such as traffic regulations.

Finally, it must be pointed out that the joining of highly innovative energy and automobile sectors in Germany brought about by electromobility also opens up tremendous new potential for research. The close interweaving of the topics regarding the smart grid and electromobility will lead to an extension of valuable system competencies in the energy management and technology sectors, the automobile industry and the communications industry, and give the German economy a competitive edge.

C.2 How standardisation can benefit electromobility

Benefits for the state and society

Economic advantages

- Opening up new markets and maintaining a foothold on existing markets through the international standardisation of electromobility, thus facilitating exports.
- Successful market penetration by innovations “made in Germany” as a result of widespread acceptance and low implementation costs, particularly during the introduction and expansion phase, which is of prime importance to German industry.

Benefits for the general public and consumers

- The high levels of safety, availability, reliability and interoperability already achieved in other sectors in Germany can also be achieved for electromobility products through the early standardisation of relevant requirements and interfaces.
- Standardisation gives customers more confidence in their own decisions, thus accelerating the market penetration of electromobility.

Benefits for the automobile manufacturing industry

- In order to sustainably maintain the German automobile industry’s technological lead, nationally harmonised research as well as standardisation and regulatory action are required to create suitable framework conditions for targeting future developments and to ensure export opportunities.
- Consensus-based standards and specifications will provide investment security for research and development by the German automobile industry, which is highly innovative by international comparison. Market shares can be secured and expanded by ensuring modular design and interoperability of the entire solution portfolio.

Benefits for component suppliers, the electrical industry, SMEs, trades and testing institutes

- Well-defined criteria for product and testing standards will give the electrical engineering industry and associated trades investment and legal security.
- New market and export opportunities at national, European and global levels will be created for the electrical engineering industry. Uniform international standards, both for grid-to-vehicle connections and for the actual vehicles are tremendously important in this context.
- German inspection, testing and certification bodies have been very successful on the international stage in recent years. They have profited from the positive image that German engineering has achieved abroad, while at the same time themselves contributing towards enhancing this image. New market opportunities will also be created by defining criteria for product, testing and safety standards early and on an international scale.

Benefits for charging infrastructure operators

- Standardised components and interfaces allow the identification of "correct" hardware in terms of compatibility (plugs) and the charging technology offered by competing suppliers; this will result in long-term security of investments.
- Standard charging procedures and vehicle power categories make it possible to determine the power requirements for a consumer terminal. This allows the selection of the "most economical" grid connection and makes it possible to provide for corresponding power demands.
- The charging infrastructure market is dependent on the introduction of electromobility. Standardisation will allow participation of numerous competitors in the market as it will prevent monopoly situations or the development of such.

Benefits for grid operators

- Improved planning certainty for grid expansion (e.g. for more power at consumer terminal points) by standardising the power classes for charging equipment and charging methods.
- Simplification of charging station connection procedures, e.g. by conformity to consumer terminal connection regulations.

Benefits for energy traders and electricity generating companies

The advantages described in Annex C.1 can only be exploited on the basis of uniform standards regulating the integration of electric vehicles into the balancing energy market

Opportunities for service providers

- Standardised communication interfaces for dynamic pricing information enable the provision of "energy trader" services.
- A standardised method of determining the resale value of used batteries is of vital importance to financing companies and used-car traders. It would also allow the development of services involving other secondary utilisation of used batteries.

Benefits for battery manufacturers

Dedicated standardisation of batteries as energy storage media for external applications would provide distinct advantages for battery manufacturers. However, since the battery geometry requirements of individual vehicles will differ, one can hardly expect that these will be standardised. Demands for this kind of standardisation might arise if a battery swapping concept were to achieve wider acceptance.

Regardless of these issues, the following subjects are suitable for standardisation.

- Technical performance specifications of battery systems: this applies, for instance, to the methods of determining data and specifications on electric charging and discharging performance as a function of operating temperature and charge. Methods for determining the service life of battery systems (charging cycles achieved and absolute service life in calendar terms) could be subjects for standardisation. Corresponding standards for portable device batteries and industrial batteries could be used as examples for the development of such standards.
- Safety of battery systems: the battery, as a high-voltage component, must be classified as a critical component. Standardising the interfaces between the battery and the vehicle (plug and socket systems, data interfaces etc.) can help to facilitate handling and maintenance and minimise the risks involved.
- Standardising identification and labelling (technical data, materials and contents, recycling information) of battery systems is also in the interest of battery manufacturers and consumers.
- Safety testing: the standardisation of safety tests to simulate misuse, as well as the ability of vehicle batteries to withstand crash conditions in practical applications could help to establish uniform conditions for all market participants, and thus create a well-defined orientation framework. This might have a positive effect on battery system development costs and on the purchase of standard components.
- Battery system sub-components: as already explained above, the external geometry of battery systems will probably not be standardised, but it is conceivable that standards may be defined for the storage cells, which are the smallest sub-component of an electro-chemical energy storage battery system. Especially the height of the cells is considered to be decisive for their use in batteries, which usually have an extremely flat design. Standardisation of cell geometry and of the electrical terminals could limit the variety of product designs and therefore help to reduce costs. A possible further standardisation approach could involve standardising modules, each comprising several cells.
- Standardising of interoperability for battery replacement systems, e.g. electrical interfaces, will lead to investment security in the relevant industry sector.

Annex D Overview of standards, specifications and standardisation bodies relating to electromobility

D.1 Standards and specifications, August 2014

Standards and specifications				Domain		
Standard or specification	**National body**	**Title**	**Status**	**Vehicle**	**Energy storage**	**Charging infrastructure**
EN 50160	UK 767.1	Voltage characteristics of electricity supplied by public distribution networks	IS			
EN 55012 (CISPR 12)	K 767	Vehicles, motorboats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of off-board receivers	IS			
EN 55025 (CISPR 25)	K 767	Vehicles, motorboats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers	IS			
IEC 60364-5-53 Edition 3.1 DIN VDE 0100-530	K 221	Low voltage installations – Part 530: Selection and erection of electrical equipment – Switch-gear and control gear	IS			
IEC 60364-5-54 Edition 3 DIN VDE 0100-540	UK 221.1	Low voltage installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors	IS			
IEC 60364-7-722	AK 221.1.11	Low voltage electrical installations – Part 7-722: Requirements for special installations or locations – Supply of electric vehicles	CDV			
HD 60364-7-722 / DIN VDE 0100-722	AK 221.1.11	Low voltage electrical installations – Part 7-722: Requirements for special installations or locations – Supply of electric vehicles	EN			
IEC 60364-4-41 Edition 5 DIN VDE 0100-410	UK 221.1	Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock	IS			
IEC/TS 60479-1 Edition 4 (VDE 0140-479-1)	UK 221.1	Effects of current on human beings and live-stock – Part 1: General aspects	IS			
IEC 60529 Amendment 2 Edition 2	K 212	Degrees of protection provided by enclosures (IP Code)	IS			

Standard or specification	National body	Title	Status	Vehicle	Energy storage	Charging infrastructure
IEC 61000-6-2 Edition 3	UK 767.3	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments	CD			
IEC 61000-6-3 Edition 2	K 767	Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments	IS			
IEC 61140 Edition 4 (VDE 0140-1)	UK 221.1	Protection against electric shock – Common aspects for installations and equipment	CDV			
IEC/TS 61439-7	AK 431.1	Low-voltage switchgear and controlgear assemblies – Part 7: Assemblies for specific applications such as marinas, camping sites, market squares, electric vehicles charging stations	PAS			
IEC 61508 Part 1–7 Edition 2	GK 914	Functional safety of electrical/electronic/programmable electronic safety-related systems	IS			
IEC 61850-7-420 Edition 2	K 952	Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Distributed energy resources logical nodes	AMW			
IEC 61851-1 Edition 3	GAK 353.0.4	Electric vehicle conductive charging system – Part 1: General requirements	CD			
IEC 61851-21 Edition 2	AK 353.0.6	Electric vehicle conductive charging system – Part 21: Electric vehicle requirements for conductive connection to an a.c./d.c. supply	CD			
IEC 61851-21-1	AK 353.0.6	Electric vehicle conductive charging system – Part 21-1: Electric vehicle onboard charger EMC requirements for conductive connection to a.c./d.c. supply	CD			
IEC 61851-21-2	AK 353.0.6	Electric vehicle conductive charging system – Part 21-2: EMC requirements for OFF board electric vehicle charging systems	CD			
IEC 61851-22	K 353	Electric vehicle conductive charging system – Part 22: AC electric vehicle charging station	IS			
IEC 61851-23 Edition 2	GAK 353.0.2	Electric vehicle conductive charging system – Part 23: DC electric vehicle charging station	NP			
IEC 61851-24 Edition 2	GAK 353.0.2	Electric vehicle conductive charging system – Part 24: Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging	NP			

Standard or specification	National body	Title	Status	Vehicle	Energy storage	Charging infrastructure
IEC/TS 61851-3-1	GAK 353.0.9	Electric Vehicles conductive power supply system – Part 3-1: General Requirements for Light Electric Vehicles (LEV) AC and DC conductive power supply systems	CD			
IEC/TS 61851-3-2	GAK 353.0.9	Electric Vehicles conductive power supply system – Part 3-2: Requirements for Light Electric Vehicles (LEV) DC off-board conductive power supply systems	CD			
IEC/TS 61851-3-3	GAK 353.0.9	Electric Vehicles conductive power supply system – Part 3-3: Requirements for Light Electric Vehicles (LEV) battery swap systems	ANW			
IEC/TS 61851-3-4	GAK 353.0.9	Electric Vehicles conductive power supply system – Part 3-4: Requirements for Light Electric Vehicles (LEV) communication	ANW			
IEC 61980-1	GAK 353.0.1	Electric vehicle wireless power transfer systems (WPT) – Part 1: General requirements	FDIS			
IEC/TS 61980-2	GAK 353.0.1	Electric vehicle wireless power transfer (WPT) systems – Part 2: Specific requirements for communication between electric road vehicle (EV) and infrastructure with respect to wireless power transfer (WPT) systems	ANW			
IEC/TS 61980-3	GAK 353.0.1	Electric vehicle wireless power transfer (WPT) systems – Part 3: Specific requirements for the magnetic field power transfer systems	ANW			
IEC 62196-1 Edition 3	GAK 542.4.1	Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 1: General requirements	IS			
IEC 62196-2 Edition 2	GAK 542.4.1	Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories	CD			
IEC 62196-3	GAK 542.4.1	Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 3: Dimensional compatibility and interchangeability requirements for d.c. and a.c./d.c. pin and contact-tube vehicle couplers	IS			
IEC/TS 62196-4	GAK 542.4.1	Plugs, socket-outlets, and vehicle couplers – Conductive charging of electric vehicles – Part 4: Dimensional compatibility and interchangeability requirements for a.c., d.c. and a.c./d.c. vehicle couplers for Class II or Class III light electric vehicles (LEV)	ANW			

Standard or specification	National body	Title	Status	Vehicle	Energy storage	Charging infrastructure
IEC 62351 Parts 1–8	K 952	Power systems management and associated information exchange – Data and communications security	TS			
IEC 62351 Part 10	K 952	Power systems management and associated information exchange – Data and communications security – Part 10: Security architecture guidelines	TR			
IEC TR 62443-3-1	AK 931.1	Industrial communication networks – Network and system security – Part 3-1: Security technologies for industrial automation and control systems	TR			
IEC 62576 Edition 2	K 331	Electric double-layer capacitors for use in hybrid electric vehicles – Test methods for electrical characteristics	AMW			
IEC 62660-1	K 371	Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 1: Performance testing	IS			
IEC 62660-2	K 371	Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 2: Reliability and abuse testing	IS			
IEC 62660-3	K 371	Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 3: Safety requirements of cells and modules	CD			
IEC 62752	AK 541.3.6	In-Cable Control and Protection Device for mode 2 charging of electric road vehicles (IC-CPD)	CDV			
IEC 62831	AK 353.0.8	User identification in Electric vehicle Service Equipment using a smartcard	ANW			
IEC 62840-1	AK 353.0.7	Electric vehicle battery swap system – Part 1: System description and general requirements	CD			
IEC 62840-2	AK 353.0.7	Electric vehicle battery swap system – Part 2: Safety requirements	CD			
IEC 62893	UK 411.2.8	Charging cables for electric vehicles	ANW			
23E/853/NP	AK 541.3.7	Residual Direct Current Monitoring Device to be used for Mode 3 charging of Electric Vehicle (RDC-MD)	ANW			
VDE 0105-100	K 224	Operation of electrical installations – Part 100: General requirements	IS			

Standard or specification	National body	Title	Status	Vehicle	Energy storage	Charging infrastructure
ISO 6469-1 Edition 2	052-01-21 AA	Electric propelled road vehicles – Safety specifications – Part 1: On-board rechargeable energy storage system (RESS)	IS			
ISO 6469-2 Edition 2	052-01-21 AA	Electric propelled road vehicles – Safety specifications – Part 2: Vehicle operational safety means and protection against failures	IS			
ISO 6469-3 Edition 2	052-01-21 AA	Electric propelled road vehicles – Safety specifications – Part 3: Protection of persons against electric shock	IS			
ISO 6469-4	052-01-21 AA	Electrically propelled road vehicles – Safety specifications – Part 4: Post crash electrical safety	DIS			
ISO 6722-1 Edition 4	052-01-03-04 AK	Road vehicles – 60 V and 600 V single-core cables – Part 1: Dimensions, test methods and requirements for copper conductor cables (Ed. 2.0)	IS			
ISO 6722-2 Edition 4	052-01-03-04 AK	Road vehicles – 60 V and 600 V single-core cables – Part 2: Dimensions, test methods and requirements for aluminium conductor cables	IS			
ISO 7637-1 Edition 3	052-01-03-03 GAK UK 767.13	Road vehicles – Electrical disturbances by conduction and coupling – Part 1: Definitions and general considerations	CD			
ISO 7637-2 Edition 3	052-01-03-03 GAK UK 767.13	Road vehicles – Electrical disturbances by conduction and coupling – Part 2: Electrical transient conduction along supply lines only	IS			
ISO 7637-3 Edition 3	052-01-03-03 GAK UK 767.13	Road vehicles – Electrical disturbances by conduction and coupling – Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines	DIS			
ISO TR 8713	052-01-21 AA	Electrically propelled road vehicles – Vocabulary	TR			
ISO 10924-5	052-01-03-05 AK	Road vehicles – Circuit breakers – Part 5: Circuit breakers with tabs with rated voltage of 450 V	DIS			
ISO 11451-1 Edition 4	UK 767.13	Road vehicles – Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 1: General principles and terminology	IS			
ISO 11451-2 Edition 4	UK 767.13	Road vehicles – Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 2: Off-vehicle radiation sources	FDIS			

Standard or specification	National body	Title	Status	Vehicle	Energy storage	Charging infrastructure
ISO 11451-3 Edition 3	UK 767.13	Road vehicles – Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 3: On-board transmitter simulation	FDIS			
ISO 11452-1 Edition 4	UK 767.13	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 1: General principles and terminology	FDIS			
ISO 11452-2 Edition 2	UK 767.13	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 2: Absorber-lined shielded enclosure	IS			
ISO 11452-3 Edition 3	UK 767.13	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 3: Transverse electromagnetic mode (TEM) cell	AWI			
ISO 11452-4 Edition 4	UK 767.13	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Harness excitation methods	IS			
ISO 11452-5 Edition 2	UK 767.13	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 5: Stripline	IS			
ISO 11452-7 Edition 2	UK 767.13	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 7: Direct radio frequency (RF) power injection	IS			
ISO 11452-8 Edition 2	UK 767.13	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 8: Immunity to magnetic fields	FDIS			
ISO 11452-9	UK 767.13	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 9: Portable transmitters	IS			
ISO 11452-10	UK 767.13	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 10: Immunity to conducted disturbances in the extended audio frequency range	IS			
ISO 12405-1	052-01-21-03 GAK	Electrically propelled road vehicles – Test specification for lithium-ion traction battery packs and systems – Part 1: High-power applications	IS			

Standard or specification	National body	Title	Status	Vehicle	Energy storage	Charging infrastructure
ISO 12405-2	052-01-21-03 GAK	Electrically propelled road vehicles – Test specification for lithium-ion traction battery packs and systems – Part 2: High-energy applications	IS			
ISO 12405-3	052-01-21-03 GAK	Electrically propelled road vehicles – Test specification for lithium-ion traction battery packs and systems – Part 3: Safety performance requirements	IS			
ISO 14572 Edition 3	052-01-03-04 AK	Road vehicles – Round, sheathed, 60 V and 600 V screened and unscreened single- or multi-core cables – Test methods and requirements for basic and high-performance cables	IS			
ISO 15118-1	052-01-03-17 AK	Road vehicles – Vehicle to grid communication interface – Part 1: General information and use-case definition	IS			
ISO 15118-2	052-01-03-17 AK	Road vehicles – Vehicle to grid communication interface – Part 2: Network and application protocol requirements	IS			
ISO 15118-3	052-01-03-17 AK	Road vehicles – Vehicle to grid communication interface – Part 3: Physical and data link layer requirements	FDIS			
ISO 15118-4	052-01-03-17 AK	Road vehicles – Vehicle to grid communication interface – Part 4: Network and application protocol conformance test	FDIS			
ISO 15118-5	052-01-03-17 AK	Road vehicles – Vehicle to grid communication interface – Part 5: Physical layer and data link layer conformance test	CD			
ISO 15118-6	052-01-03-17 AK	Road vehicles – Vehicle to grid communication interface – Part 6: General information and use-case definition for wireless communication	CD			
ISO 15118-7	052-01-03-17 AK	Road vehicles – Vehicle to grid communication interface – Part 7: Network and application protocol requirements for wireless communication	AWI			
ISO 15118-8	052-01-03-17 AK	Road vehicles – Vehicle to grid communication interface – Part 8: Physical layer and data link layer requirements for wireless communication	AWI			
ISO/IEC 15408-1 Edition 3	043-01-27-03 AK	Information technology – Security techniques – Evaluation criteria for IT security – Part 1: Introduction and general model	IS			
ISO 16750, Parts 1–5	052-01-03-13 AK	Road vehicles – Environmental conditions and testing for electrical and electronic equipment	IS			

Standard or specification	National body	Title	Status	Vehicle	Energy storage	Charging infrastructure
ISO/IEC PAS 16898	052-01-21-03 GAK	Electrically propelled road vehicles – Dimensions and designation of secondary lithium-ion cells	PAS			
ISO 17409	052-01-21 AA	Electrically propelled road vehicles – Connection to an external electric power supply – Safety requirements	DIS			
ISO 17840	052-01-12 AA	Road vehicles – Information for first and second responders – Rescue sheet for passenger cars and light commercial vehicles	DIS			
ISO 18243	052-01-23 AA	Electrically propelled mopeds and motorcycles – Specifications and safety requirements for lithium-ion traction battery systems	CD			
ISO 18300	052-01-21-03 GAK	Electrically propelled road vehicles – Specifications for lithium-ion battery systems combined with lead acid battery or capacitor	DIS			
ISO PAS 19295	052-01-21-01 GAK	Electrically propelled road vehicles – Specification of voltage sub-classes for voltage class B	AWI			
ISO PAS 19363	052-01-21 AA	Electrically propelled road vehicles – Magnetic field wireless power transfer – Safety and interoperability requirements	AWI			
ISO 19453-1	052-01-03-13 AK	Road vehicles – Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles – Part 1: General	AWI			
ISO 19453-2	052-01-03-13 AK	Road vehicles – Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles – Part 2: Electrical loads	AWI			
ISO 19453-3	052-01-03-13 AK	Road vehicles – Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles – Part 3: Mechanical loads	AWI			
ISO 19453-4	052-01-03-13 AK	Road vehicles – Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles – Part 4: Climatic loads	AWI			
ISO 19642 Parts 1–10	052-01-03-04 AK	Road vehicles – Automotive cables	NP			
ISO 23273	052-01-21 AA	Fuel cell road vehicles – Safety specifications – Protection against hydrogen hazards for vehicles fuelled with compressed hydrogen	IS			

Standard or specification	National body	Title	Status	Vehicle	Energy storage	Charging infrastructure
ISO 23274-1	052-01-21 AA	Hybrid-electric road vehicles – Exhaust emissions and fuel consumption measurements – Part 1: Non-externally chargeable vehicles	IS			
ISO 23274-2	052-01-21-02 AK	Hybrid-electric road vehicles – Exhaust emissions and fuel consumption measurements – Part 2: Externally chargeable vehicles	IS			
ISO 26262 Part 1–10	052-01-26 AA	Road vehicles – Functional safety	IS			
ISO/IEC 27000 Edition 3	043-01-27-01 AK	Information technology – Security techniques – Information security management systems – Overview and vocabulary	IS			
ISO/IEC 27001 Edition 2	043-01-27-01 AK	Information technology – Security techniques – Information security management systems – Requirements	IS			
DIN SPEC 70121	052-01-03-17 AK	Electromobility – Digital communication between a DC EV charging station and an electric vehicle for control of DC charging in the Combined Charging	PUB			
SAE J 1773		Electric Vehicle Inductively Coupled Charging	PUB			
SAE J 1797		Recommended Practice for Packaging of Electric Vehicle Battery Modules	PUB			
SAE J 1798		Recommended Practice for Performance Rating of Electric Vehicle Battery Modules	PUB			
SAE J 2288		Life Cycle Testing of Electric Vehicle Battery Modules	PUB			
SAE J 2289		Electric-Drive Battery Pack System: Functional Guidelines	PUB			
SAE J 2464		Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing	PUB			
SAE J 2929		Safety Standard for Electric and Hybrid Vehicle Propulsion Battery Systems Utilizing Lithium-based Rechargeable Cells	PUB			

D.2 Standardisation bodies within DIN, NAAutomobil and the DKE

Bodies within DIN / NAAutomobil

- NA 043-01-27 AA: IT Security Techniques
- NA 052-01-03 AA: Electrical and electronic equipment
- NA 052-01-03-01 AK: Data communication
- NA 052-01-03-03 GAK: Joint working group DKE / NAAutomobil, EMV (DKE/UK 767.13)
- NA 052-01-03-04 AK: Electric vehicle cables
- NA 052-01-03-05 AK: Fuses
- NA 052-01-03-06 AK: Plug connections
- NA 052-01-03-13 AK: Environmental conditions
- NA 052-01-03-16 AK: Functional safety
- NA 052-01-03-17 AK: Communication / EV power grid
- NA 052-01-21 AA: Electric road vehicles
- NA 052-01-21-04 AK: Vehicle systems for electric propulsion
- NA 052-01-21-05 AK: Wireless charging
- NA 052-01-26-01 AK: General requirements for road vehicles

Bodies within DKE

- DKE/K 116: Graphic symbols for man-machine interaction; safety marking
- DKE/AK 221.1.11: System appraoch to electric vehicle connection (protection against electric shock)
- DKE/K 261: System aspects of electric power supply
- DKE/K 331: Power electronics
- DKE/K 353: Electric road vehicles
- DKE/AK 353.0.6: EMC in supplying energy to electric vehicles
- DKE/AK 353.0.7: Battery changing systems
- DKE/AK 353.0.8: User authorisation in charging infrastructures
- DKE/K 371: Accumulator batteries (development of standards for batteries and their requirements)
- DKE/UK 411.2.8: Cables for electric vehicles
- DKE/GAK 431.1.7: Distributors for temporary connection to consumers (GAK within DKE)
- DKE/K 461: Electricity meter
- DKE/AK 541.3.7: Monitoring and switch-off device for mode 3 charging
- DKE/AK 542.1.2: Household plug accessories
- DKE/K 764: Safety in electromagnetic fields
- DKE/GUK 767.14: Radio interference suppression of vehicles, vehicle equipment and combustion engines
- DKE/AK 952.0.15: Information protection in the network and station control system
- DKE/AK STD 1113.0.3: Use Cases for E-Mobility
- DKE/K STD1911: Steering committee standardisation of “E-Energy / Smart Grids”
- DKE/UK STD1911.5: Network integration electromobility for E-Energy / Smart Grids
- DKE/UK STD1911.11: Information security for E-Energy / Smart Grid
- DKE/STD 1911.11.5: Information security for electromobility

Joint bodies of DKE and NAAutomobil

- DKE/EMOBILITY: EMOBILITY steering committee of DKE and NAAutomobil
- DKE/EMOBILITY.30: Standardisation Roadmap for E-Mobility
- DKE/EMOBILITY.40: Mirror committee of the German-Chinese sub-working group on electromobility
- DKE/EMOBILITY.50: Focus group on batteries
- DKE/GAK 353.0.1: Inductive charging of electric vehicles
- DKE/GAK 353.0.2: DC charging of electric vehicles
- DKE/GAK 353.0.4: AC charging of electric vehicles
- DKE/GAK 353.0.9: Energy supply for Light Electric Vehicles
- DKE/GAK 541.3.6: Protective devices for electromobility
- DKE/GAK 542.4.1: Accessories for connecting vehicles to the grid my means of cables
- DKE/GAK 542.4.3: DC accessories for connecting vehicles to the grid my means of cables
- DKE/GAK 767.13.18 (NA 052-01-03-03 GAK): EMC electromobility
- NA 052-01-03-17 GAK: Communication interface from vehicle to electricity grid (V2G CI)
- NA 052-01-21-01 GAK: Electrical safety and grid interface
- NA 052-01-21-03 GAK: Traction batteries for electric vehicles

Annex E Current status of the implementation of recommendations, August 2014

Short-term <1 year

Medium/long-term >1 year

Current status of the implementation of recommendations			
No.	**Recommendation**	**Responsible body**	**Implementation by**
EM – Electromagnetic compatibility (EMC)			
4.4.7.2	Quick development of IEC 61851-21-1 “Electric vehicle conductive charging system – Part 21-1: Electric vehicle onboard charger EMC requirements for conductive connection to a.c./d.c. supply”	DKE, NAAuto	
4.4.7.2	Quick development of IEC 61851-21-2 “Electric vehicle conductive charging system – Part 21-2: EMC requirements for OFF board electric vehicle charging systems”	DKE, NAAuto	
ES – Electrical safety			
4.4.7.1	Quick conclusion of IEC 60364-7-722 “Low voltage electrical installation – Part 7-722: Requirements for special installations or locations – Supply of electric vehicles” and implementation of a new version of DIN VDE 0100-722	DKE	
4.4.7.1	Quick conclusion of revision of standards series IEC 61851 “Electric vehicle conductive charging system”	DKE	
4.3.5.1	Quick conclusion of work on IEC 62660-3 “Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 3: Safety requirements of cells and modules”	DKE, NAAuto	
4.4.7.4	Development of technical rules and standard guidelines for inspection of an electric installation under consideration of special features of the charging infrastructure for electromobility	DKE	
4.4.7.4	Review whether instructions for installation and maintenance of charging infrastructure should be supported with specifications and standards	DKE	
4.4.7.4	Revision of standard DIN VDE 0105-100 concerning scope of application	DKE	
4.4.7.1	Revision or development of respective standard for electrical safety for the connection (DC charging) of vehicles with battery voltages over 400 V	DKE	
FL – Recommendations for the research landscape			
4.3.3.1	Research and implementation: battery status after accident		
4.3.5.1	Research and implementation in standard: determination of battery service life by saving the required parameters		
4.3.1.1	Research and implementation in standard: load spectra		
4.3.7.1	Research and implementation in standard: capacitators (including ultra-caps)		

Current status of the implementation of recommendations			
No.	**Recommendation**	**Responsible body**	**Implementation by**
FS – Functional safety			
4.4.7.3	Development of a work instruction standard to achieve required SILs for installation of charging stations	DKE	
4.4.7.3	Review requirement for work instruction specifications and standards for use of cables at charging stations	DKE	
LV – Performance and consumption characteristics			
4.2.3.1	Initiation and development of an economically applicable metering method for DC charging by NPE AG 3 and NPE AG 4	NPE AG 3 NPE AG 4	
4.3.4.1	Review on expansion and adaptation of ISO 16750 “Road vehicles – Environmental conditions and testing for electrical and electronic equipment” for electric vehicles	NAAuto	
4.3.4.1	Quick development of ISO/AWI 19453-3: “Road vehicles – Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles – Part 3: Mechanical loads” under German management	NAAuto	
4.3.4.1	Quick development of ISO/AWI PAS 19295 “Electrically propelled road vehicles – Specification of voltage sub-classes for voltage class B” under German management	NAAuto	
4.3.4.1	Review of standard ISO 23828 “Fuel cell road vehicles – Energy consumption measurement – Vehicles fuelled with compressed hydrogen” for amendments	NAAuto	
4.3.4.1	Review of standards series ISO 23274 “Hybrid-electric road vehicles – Exhaust emissions and fuel consumption measurements” for amendments	NAAuto	
4.3.4.1	Review of ISO TR 11954 “Fuel Cell Road Vehicles – Maximum speed measurement” for amendments	NAAuto	
4.3.4.1	Review of ISO TR 11955 “Hybrid-electric road vehicles – Guidelines for charge balance measurement” for amendments	NAAuto	
4.3.4.1	Review of ISO 8715 “Electric road vehicles – Road operating characteristics” for amendments	NAAuto	
4.3.4.1	Consideration of standby current consumption values of electric vehicles	NAAuto	
4.3.5.1	Quick development of IEC 62660-3 “Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 3: Safety requirements of cells and modules” under German management	DKE, NAAuto	
4.3.5.1	Quick development of standard ISO 18300 “Electrically propelled road vehicles – Specifications for lithium-ion battery systems combined with lead acid battery or capacitor” under German management	DKE, NAAuto	
4.4.6.3	Development and specification of admissible internal consumption of charging infrastructure	DKE	
4.4.1	Development of standards for payment/billing of charging with non-network frequency, include specification development group of PTB	DKE	

Current status of the implementation of recommendations			
No.	**Recommendation**	**Responsible body**	**Implementation by**
SD – IT safety and data protection			
4.2.5.1	Include NA 043-01-27 AA in DKE/STD 1911.11.5	NAAuto	
SK – External interfaces and communication			
4.2.2.1	Standardising of application and communication protocol for load management	DKE	
4.2.2.1	Definition of suitable communication protocols for dynamic load management	DKE	
4.2.2.1	Include existing installation for static and dynamic load management	DKE	
4.2.2.1	Definition of minimum requirements for voltage quality during charging	DKE	
4.2.2.1	Definition and standardisation of mechanisms for controlled resumption of charging process after power failure	DKE	
4.2.2.1	Tracing and quick conclusion of ETSI DTS/ITS-0010031 “Intelligent Transport Systems (ITS); Infrastructure to Vehicle Communications; Communications system for the planning and reservation of EV energy supply using wireless networks”	DKE	
4.2.2.1	Tracing and quick conclusion of the documents ISO 15118 “Road vehicles – Vehicle to grid communication interface” – Part 6, 7 und 8	NAAuto	
4.2.2.2	Finding a national consensus on standardised interfaces and the data to be transmitted under management of NPE AG 4	DKE, NAAuto	
4.4.6.1	Recommendation for use of AC charging plug type 2 according to IEC 62196-2 for vehicle side and infrastructure side in Europe and other markets with three-phase supply	DKE	
4.4.6.2	Recommendation for use of accessories for the “Combined Charging System” for DC charging	DKE	
4.4.6.2	Convincing the USA and other countries about the advantages of “Combined Charging System” as a universal solution for DC and AC charging	DKE	
4.4.2	Revision of IEC 61851-1 so that the DC charging approach (combined charging system) is fully supported	DKE	
4.4.2	Revision of IEC 61851 Part 21 and ISO 17409, preferrably in mode 5 cooperation	DKE	
4.2.7.1	Use of graphic symbols for user interface of a charging station	DKE, NAAuto	
4.2.7.1	Examine use of graphic symbols for man-machine interaction or safety labelling, as well as standardisation demands	DKE, NAAuto	
4.2.7.1	Coordination of standardisation activities of ISO/TC 22/SC 13/WG 5 and DKE/K 116	DKE, NAAuto	
4.2.7.1	Examine standardisation demand for a uniform, barrier-free access to charging stations and initiation of additional research projects	DKE, NAAuto	
4.2.7.1	Examine other access and identification mechanisms of charging infrastructure	DKE, NAAuto	

Current status of the implementation of recommendations			
No.	**Recommendation**	**Responsible body**	**Implementation by**
4.3.2.1	Amendment to existing charging modes of IEC 61851-1 (charging mode 1 to 4) with solutions to be standardised in standards series IEC 61851-3	DKE	
4.4.3	Coordination of the German position on standard project IEC 61980-1 and combination of work on inductive charging in project IEC 61980	DKE	
4.4.3	Continuous and active participation of German experts in projects IEC/TS 61980-2 and -3	DKE	
4.4.3.1	Work on IEC-61980 series must be promoted so that the normative requirements for safe inductive charging are formulated and published for small and medium power by the end of 2015.	DKE	
4.4.3.1	Revision of IEC-61980-series so that the normative requirements for safe, interoperative inductive charging are formulated and published for small and medium power by the end of 2018.	DKE	
4.2.4.1	Further development of respective standards for energy feedback	DKE	
4.4.4.1	Amendment to IEC 61851 with topology description (special case of connection method “case C”)	DKE	
4.4.4.1	Definition of cancellation conditions and methods for interferences during the connection procedure for the safety of persons, machine, vehicle and environment	DKE	
4.4.2.1	A reference to the safety group standard DIN EN 62477-1 (VDE 0558-477-1) should be added during the revision of IEC 61851-23.	DKE	
4.4.1.1	Tracing and quick conclusion of standard project IEC62752 “In-Cable Control and Protection Device for mode 2 charging of electric road vehicles (IC-CPD)” under German management	DKE	
U – Accident			
4.3.3.1	Definition of a simple and safe identification of vehicles for rescue puposes	NAAuto	
4.3.3.1	Timely conclusion and publication of standard ISO 6469-4 under German management	NAAuto	
4.3.3.1	Timely development of standard ISO 17840 “Road vehicles – Information for first and second responders – Rescue sheet for passenger cars and light commercial vehicles” for rescue guidelines with German participation	NAAuto	
4.3.3.2	Specific guidelines must be adhered to for the storage of lithium-ion batteries to reduce fire hazards. Thus, standards must be developed over the medium-term.	DKE, NAAuto	